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Forthcoming Events.

SEPTEMBER 19.

Institute of Metals:—Annual Autumn Meeting in the rooms of the Chemical Society, Burlington House, London, W.

SEPTEMBER 20, 21.

The Iron and Steel Institute:—Autumn Meeting.

NOTES AND COMMENTS.

Merchant Traders' Difficulties.

The Merchants' Committee of the London Chamber of Commerce have made a Report on the subject of merchant trading, particularly as affected by the war, which has been adopted in principle by the Council of the Chamber. This Report points out that the Government, in the steps it has taken to regulate supplies in war time, has not sufficiently availed itself of the services of the mercantile community, with its knowledge of sources of supply and its organisation. The methods adopted have, in the judgment of the Committee, failed to produce the maximum advantages to the State, with the minimum of interference with legitimate trade usages and organisation. The results of these methods have in many respects been subversive of the objects in view. The Report continues:—

There seems to be no adequate ground for dispensing with the services of the merchant, whose relations with suppliers, and expert knowledge of the goods involved, should entitle him to be treated on reasonable terms by the State in a business with which he alone has had actual experience in the past. The conduct of this business also involves the question of finance, which influences the foreign producer in his choice of the British market. The merchant, moreover, is prepared to undertake great risks, whether in peace or war, and only asks that he shall have the opportunity of bringing into the country its essential requirements on terms which will leave a fair remuneration for these risks. The reasonable profits of *bonâ fide* distributors should be allowed, and these may justly include remuneration to the merchants or brokers whose business has been to handle the stocks they obtain from various sources before they reach the manufacturer or retail distributors.

The Committee, having regard to the foregoing considerations, recommend:—

(*a*) That Government should cease to act as trading intermediary between producers and consumers, but should utilise to the fullest extent the services of the business community.

(*b*) That to this end merchants should be encouraged to continue to carry or import stocks of commodities essential to this country.

(*c*) That, so far as any control of imports and exports is concerned, the quantities allowed should as far as possible be based upon a fair allocation of quantities amongst merchants dealing in particular articles, after consultation with representative trade organisations. Permits should only be granted to British and Allied subjects who are legitimate merchants and importers in the trade involved.

(*d*) That the various Control Departments should be co-ordinated so far as to secure a uniform system on questions of principle and to obviate present delays in dealing with licences and permits.

(*e*) That Control Departments should in all cases be assisted by representative business men nominated by their respective trades.

(*f*) That steps be taken to represent to the Government, to Members of Parliament, and the

public generally, the views set out in the Report of this Committee.

Pig-Iron and Copper Merchants.

Attached to the above Report are several appendices, including data collected by the Metal Merchants' Sub-Section of the Chamber. From the latter the following extracts are taken :—

"For generations past, before the outbreak of war, all Cleveland pig-iron has been sold to various pig-iron users all over the country, principally through the leading merchant houses, who had laid themselves out specially for handling the business by owning coasting steamers, canal lighters, horses and carts, the necessary stables and depôts. In spite of this well-known fact when control was instituted, no provision whatever was made for the protection of such merchants, and no merchants were consulted by the Government, all arrangements being left solely in the hands of makers. Loyal customers who decide to continue to buy from their regular pre-war suppliers have to pay 1½ per cent. commission for the privilege of so doing, and continue to do this in face of repeated requests from the Ministry of Munitions to buy direct from them and to ignore their old-established connections.

"With copper also, no provision has been made for merchants, although the great bulk of the trade has always been done through merchants. After a great deal of trouble loyal customers were allowed to pay a nominal commission over and above the Government fixed prices to their regular suppliers, but were not encouraged to do so, the Government in every case preferring to deal direct. Practically no orders pass through merchants now, and they have consequently lost all touch with the consuming trade as well as with sellers, viz., copper mines and copper refiners. Trade relations, existing over generations in many cases, have been broken off. Merchants have also lost all their trade with the Allied countries, as for some months they were not allowed to do any business with the Continent. Part of these restrictions have now been removed, but only after the merchants had lost touch with their regular customers, who had been driven to deal direct with producers in U.S.A. and Japan, instead of the business coming through London as before. In accordance with the wishes expressed by the Ministry of Munitions, merchants have endeavoured to get consumers to be content with less metal than their inquiries covered. In many cases where this led to correspondence between the consumer and the Ministry, the merchant has found the business taken out of his hands by the Ministry, who supplied the full quantity asked for direct."

It is, perhaps, unnecessary to enlarge on the inconvenience and difficulty experienced by consumers through the attempted elimination of the merchants in the metal trade. As we have remarked on previous occasions, the merchant in the trade is not generally what the amateur economist is fond of calling the "unnecessary middleman." He is often, in addition to being distributor, and, in a sense, financier to the user, the latter's chief guide and consultant, bringing to bear on the question of supplies a wide knowledge of classes of material and sources of supply. The small consumer in particular would be badly placed, in the matter of competition with large users, were the merchant supplier of pig-iron and metals eliminated. A Government with a strong penchant for creating officials to manage the nation's affairs would do well to consider carefully before removing a useful section of the industrial community, merely to replace it by less experienced officials.

THE Minister of Munitions has appointed Mr. A. H. Collinson, who is at present Director of Inspection in Munition Areas, to be Controller of Inspection, in place of Sir Sothern Holland, appointed to the Admiralty for special work.

The Education of Apprentices.

We have received a copy of the Report of the Committee appointed by the Council of the North-East Coast Institution of Engineers and Shipbuilders to inquire into, and make recommendations regarding, the education of apprentices. The Report, which is signed by Mr. Gerald Stoney and Mr. E. W. Fraser Smith for and on behalf of the Committee, puts forward certain recommendations, among which are the following :—

(1) That the North-East Coast Institution be appointed by the employers' associations in connection with engineering, shipbuilding, and ship-repairing on the North-East Coast, as their representatives, to act in a consultative capacity with the local education authorities for the development of apprentice training in technical education.

(2) That prospective engineering and shipbuilding apprentices be drafted at 12 to 13 years of age to junior day technical schools for a three years' course of general education, including, amongst other subjects, mathematics, mechanics, machine drawing, and manual training.

(3) That an advisory committee of representatives of the North-East Coast Institution and of employers and employees be associated with the management of these schools in a consultative capacity.

(4) That employers give preferential appointment to these youths on passing out of these schools.

(5) That a selection (a small percentage) be made from these boys of those showing exceptional ability, solidity of character, and general promise at the beginning of the apprenticeship, and that they spend half the week in the works and half in the local technical college, in which they would receive a special two years' course of technical education.

(6) That a second selection be made from these exceptional boys on the completion of the two years' course, and that these should pass direct to the University for the full engineering or naval architecture degree courses

(7) That the local education authorities or the State provide scholarships and maintenance grants, so that the poorest boy may have the full course from the elementary school to the completion of the University course without financial anxiety.

(8) That the remainder of the boys passing into the works as ordinary apprentices should be given leave from the works for at least two half days a week, and if possible three, for the purpose of attending part-time day continuation classes.

(9) That definite practical instruction be given to all apprentices by expert craftsmen in the shops throughout the whole of the apprenticeship.

The Report has been considered by five employers' associations on the North-East Coast, who are in sympathy with the objects aimed at therein. Four of these associations generally approve of the Institution's scheme, while the fifth intends to give it further consideration.

SOUTH-WESTERN POLYTECHNIC INSTITUTE.—As will be seen from the advertisement on page 503 the Metallurgical Department of the above Institute will reopen in September. The Department offers facilities for individual work in any branch of metallurgy during the day or evening, which it is thought will be of great use to men who have not the time or opportunity to take a full course. During the present crisis it is felt that the use of the laboratories, testing-room, and the instruction provided may be of considerable value. Some of the facilities afforded are enumerated in the advertisement, and any futher information can be obtained from the Secretary. (Room 65).

The Superheating of Slags and Metals During Refining, Smelting and Alloying Operations.

By J. E. Fletcher.

At the last meeting of the Iron and Steel Institute, Mr. J. E. Fletcher (President of the Staffordshire Iron and Steel Institute) specially emphasised the slag condition as influencing the refining actions within the underlying metal. He has since given some time to the preparation of a review of the slag function problem, which he presented recently before the Society of Chemical Industry at its annual meeting in Birmingham. We append the following report of the Paper :—

1. In the production of wrought-iron and steel or ingot iron in the open-hearth furnace it is becoming clearer that the mechanism of refining and alloying is that of the intimate reactions which occur between the various constituents of the pig-iron, ore and scrap charged and those of the slags used in the efficient carrying out of such processes.

The finished cold cast products are crystalline composite masses made up of more or less carbonised or otherwise alloyed crystals separated from each other by boundaries which probably always contain minute particles or films of isolating matter. It is known that such films often contain the iron oxides FeO and Fe_2O_3, together with silicates of iron and manganese. There is further evidence that occluded gases in a fine state of division occur within the crystal boundaries. Such films must tend towards the non-welding of the adjacent crystal faces when the molten or liquido-plastic crystals are being drawn together in their passage to the solid state.

The high temperatures needed in the ferrous alloy processes make the study of the reactions and of the constitutional changes in both slags and alloys exceedingly difficult; there is a sense, however, in which it may be said that the reactions at high temperatures are more simple than at lower ones. MM. Charpy, Moissan, Ruff and Goecke, as a result of experiments, have concluded that there is a progressive formation of the carbides Fe_2C, Fe_3C, and FeC at increasing temperatures until at about 2,700 deg. C. gasification of the alloy (FeC + Fe) takes place.

2. The refining and alloying slags in iron and steel processes may be divided into three types, viz., those whose temperatures of formation, fusion, and equilibrium are (1) higher, (2) approximately the same, and (3) lower than the fusion and equilibrium of the metallic alloys in contact with the slags.

The slags of type (1) are representative of blast-furnace working, where the pig-iron fusion temperatures are in the neighbourhood of 1,140 deg. C. Such slags have the composition :

$$CaO + MgO + FeO + MnO = 50 \text{ to } 55 \text{ per cent.},$$
$$SiO_2 + Al_2O_3 + P_2O_5 = 45 \text{ to } 50 \text{ per cent.},$$

the fusion temperatures of which are in the region of 1,400 deg. C.

The slags of type (2) are typical of the puddling process where the fusion and softening temperatures of the metal being operated upon vary from 1,130 deg. to 1,450 deg. C., the slags having fusion temperatures varying between 1,080 deg. C. and 1,350 deg. C. and are silicates of iron and manganese of the approximate analysis :

$$FeO + Fe_2O_3 + MnO = 70 \text{ to } 80 \text{ per cent.}$$
$$SiO_2 = 20 \text{ to } 30 \text{ per cent.}$$

The slags of type (3) are representative of the open-hearth steel-melting processes. Here the metal fusion temperatures vary from 1,130 deg. to 1,500 deg. C.

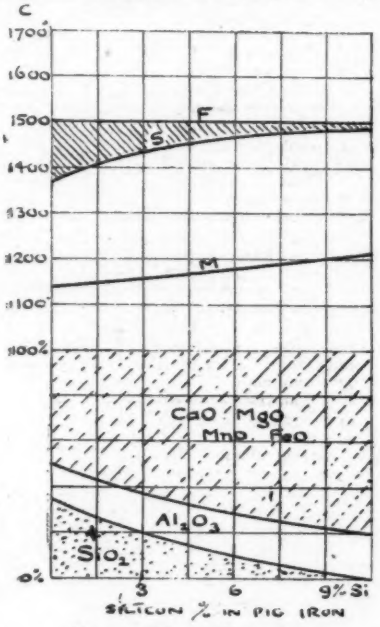


Fig. 1.—Blast Furnace.

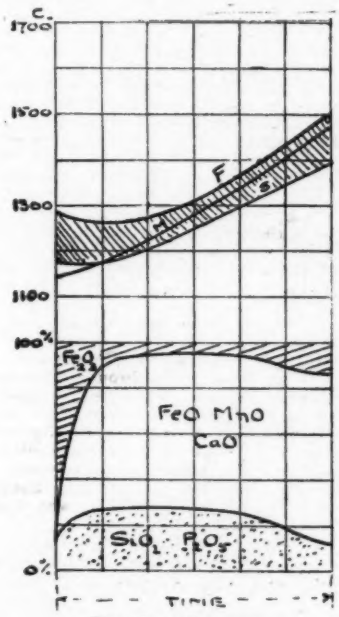


Fig. 2a.—Puddling.

F = Furnace Temperature. S = Slag Fusion Temperature. M = Metal Fusion Temperature.

whilst the slags fuse at between 1,100 deg. C. and 1,350 deg. C. and have the typical analyses :—

$CaO + MgO + FeO + MnO = 40$ to 50%) (acid
$SiO_2 + Al_2O_3 = 50$ to 60%) process).

$CaO + MgO + FeO + MnO = 80$ to 70%) (basic
$SiO_2 + P_2O_5 = 20$ to 30%) process).

3. Now obviously the temperatures of refining, smelting, and alloying chambers or hearths of the furnaces being operated must be kept higher than those of the slags or metals under treatment. Hence in case (1) the blast-furnace metal is superheated above its fusion point; in (2) the puddled iron and slags may be kept nearly at their proper fusion temperatures; and in (3) the slags are superheated above their fusion temperatures. Taking as concrete examples the cases cited :

(1) *Blast-furnace Slags.*—Here the slag fusion temperature is higher than that of the contact metal. The temperatures of the tuyere zone are in the region of 1,500 deg. C., the slag fusion temperatures being between 1,350 deg. C. and 1,450 deg. C., whilst the underlying metal is melted at roughly 1,140 deg. C. The slag and metal are therefore continuously superheated above their fusion temperatures. The metal in the hearth is primarily of eutectic composition or thereabouts, viz., 4.3 per cent. carbon, 95.7 per cent. iron. The result of superheating this eutectic is first to render the contained carbide of iron Fe_3C unstable. The higher it is heated above its melting point, 1,130 to 1,135 deg. C., the greater is this instability apparent and its sensitiveness to refining or alloying action increased. Similarly the oxide constituents of the slag which are reducible at the hearth temperatures become unstable under conditions of superheat, the silica, SiO_2, and phosphate of lime, $4CaOP_2O_5$, being readily reducible.

At the hearth temperatures, 1,500 deg. to 1,600 deg. C., the slag composition tends to adjust itself by parting with SiO_2 and P_2O_5 until it attains equilibrium consistent with the degree of superheat. If given sufficient time at, say, 1,500 deg. C., an equilibrium corresponding to the slag composition 20 per cent. Al_2O_3, 80 per cent. CaO.MgO would arrive in the case of a smelting using a working slag of primary non-superheated analysis 30 per cent. SiO_2, 15 per cent. Al_2O_3, 55 per cent. CaO.MgO. The 1,500 deg. C. saturated slag would then be inert, there being no further reducible constituent present in the slag. The metal in contact with the slag would also have moved towards stable equilibrium, and it can be shown that in the case of ferro-silicon manufacture an alloy of composition C. 5 per cent., Si 9.3 per cent., Fe 90.2 per cent. would result when the slag becomes inert. The fusion temperature of resulting slag and metal would be about 1,450 deg. C. (In this case phosphorus, sulphur, and manganese have been omitted for the sake of simplicity.)

It is impossible at present to state the composition which corresponds to the stable equilibria of slags at varying temperatures or of the metallic alloys in contact therewith, but it may be inferred from the foregoing that by proper adjustment of the primary slag composition it is possible by correct temperature control to regulate the alloying actions in the metal.

It is clear that the cast-iron becomes alloyed with silicon and phosphorus at the expense of its carbon the more readily as the slag is superheated and hence free to act on a superheated metal (unstable) in contact with it. Fig. 1 illustrates the changes in the composition and temperature of equilibrium during the progressive alloying of a white iron with silicon. The active and relatively inert conditions of the slag are indicated by the shaded area marked "superheat." The higher the superheat the more active the slag and the more unstable the metalloid compounds in the metal attacked.

There are, doubtless, cases where, as in certain pneumatic refining and smelting processes, the excess of oxygen leads to oxidation of the metal underlying the slag. Such oxides may there rise to the surface and enter the slag which under certain temperature conditions may become more active, increasing the slag superheat because of the addition of iron oxide to the slag and coincidently lowering its fusion point. Carbon in a pig-iron charge may thus be oxidised at the expense of iron oxides FeO, Fe_2O_3 in the slag, iron passing back into the metal; such action being coincident with or preceding the silicon or phosphorus transfer. Thus a blast-furnace slag may become rich in FeO, the resulting pig-iron being white. Iron has then

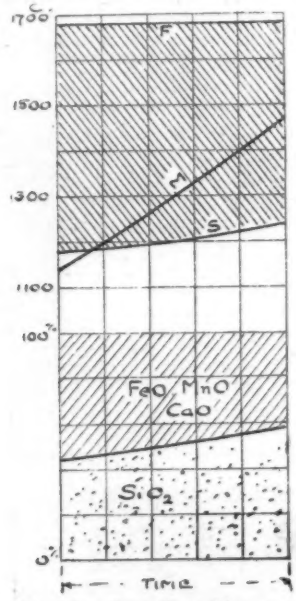


FIG. 2*b*.—ACID OPEN-HEARTH.
F = Furnace Temperature. S = Slag Fusion Temperature.

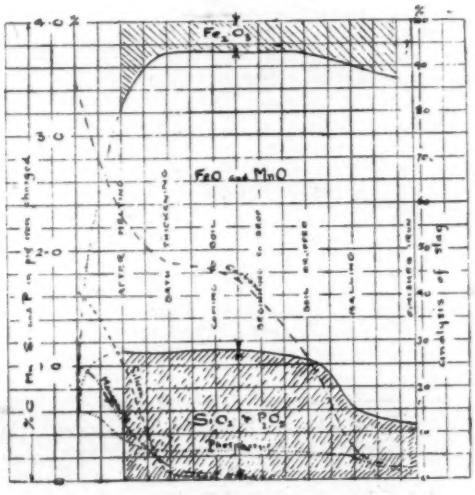


FIG. 3.
M = Metal Fusion Temperature.

been reduced from the slag in preference to silicon, and the total carbon content of the pig-iron is lower than in the case where a normal slag free from FeO has been employed.

Puddling Slags.—In the puddling process the slags are of the type (FeO, Fe_2O_3, SiO_2) having temperatures of fusion and equilibrium not much different from those of the pig-irons which it is desired to refine. Here it is necessary to desiliconise, dephosphorise, and de-

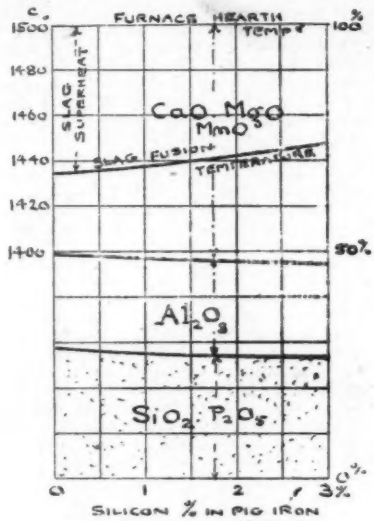


FIG. 4.—BLAST FURNACE.

carburise the pig-iron underlying or in contact with the slag. The initial fusion temperature of the pig-iron to be refined is about 1,140 deg. C., that of the first superposed slag being, say, 1,260 deg. C. This slag is therefore superheated and consequently active. Unlike the blast-furnace slag the puddling slag is basic and continues so throughout the process. There is no deterrent or inert constituent such as lime or alumina, hence temperature variations rapidly alter the slag constituency. The active iron oxides in the slag attack the unstable iron phosphide and silicide in the pig-iron and primarily furnish the oxide for gasifying the unstable carbon in the superheated iron-carbon alloy and for oxidising the silicon and phosphorus which are also but feebly stable at temperatures above 1,100 deg. C. There is an automatic adjustment of the slag composition throughout the process. At the beginning and end of the operation the temperatures are higher than during the intermediate stage. The initial and final slags are therefore high in FeO, Fe_2O_3, and low in SiO_2, whereas in the intermediate stage the slag is more siliceous and more readily fusible. During "rash" or careless working the end of the operation is conducted at too high a temperature; hence the slag is too highly superheated and adjusts its composition by robbing the iron bath or sponge. The iron oxide thus added to the slag is largely the result of oxidation by the furnace gases (rich in O and CO_2). Fig. 2 illustrates the foregoing actions. It is seen that the superheat is not so great as in the blast-furnace operation. Fig. 3 shows the progress of refining and the coincident slag adjustment composition during the complete puddling process, and illustrates most clearly the effect of superheat on the slag and metal equilibria.

4. (A) In the production of certain alloy steel the effect of superheating the working slags results in the pronounced separating out of the most readily reduced slag constituent. Thus in the making of manganese steel in the open-hearth furnace the primary slag covering the molten pig-iron charge was a rich ferrous slag of the composition approximately $FeO \cdot Fe_2O_3 = 80$ per cent. $SiO_2 = 20$ per cent. fusible at about 1,300 deg. C. Into this a pyrolusite ore of analysis $MnO_2 = 85$ per cent., $CaO.MgO = 5$ per cent., $SiO_2 = 10$ per cent., was gradually added. The MnO_2 becomes MnO on superheating, the FeO being changed to Fe_2O_3 by the O liberated from the MnO_2. It was then found that the FeO and Fe_2O_3 in the slag, if increased by further additions of hematite ore (Fe_2O_3) and lime, caused a rapid reduction of the Mn from the slag, Mn entering the liquid metal. When the slag contained over 50 per cent. of Mn then manganese entered the metal, whereas if the slag was adjusted so as to contain above 50 per cent. of Fe, then iron was reduced from the slag in preference to manganese. An increase in the superheat in either case increased the rapidity of the reduction. The temperature was not measured, but it was noticed that the higher MnO slags were more fluid than the rich FeO slags, and were apparently fusible at a lower temperature. Hence at the practically constant furnace temperature the high MnO slags were more highly superheated than the high FeO slags, hence more unstable, and then Mn in consequence more readily reduced.

(B) The refining of alloys may be illustrated in the case of the elimination of manganese in the puddling or open-hearth steel processes. Thus the reaction between the slag constituent FeO. Fe_2O_3 and the alloy constituent Mn_3C in the pig-iron is of the type:

$$FeO.Fe_2O_3 + Mn_3C = 3MnO + CO + 3Fe.$$

Manganous oxide displaces the iron oxides in the slag, the manganese in the pig-iron being replaced by pure iron from the reduction of the iron oxides. Superheating the slag renders the $FeO.Fe_2O_3$ more active, whilst that of the molten pig-iron increases the instability of the Mn_3C. In the interaction CO gas is liberated.

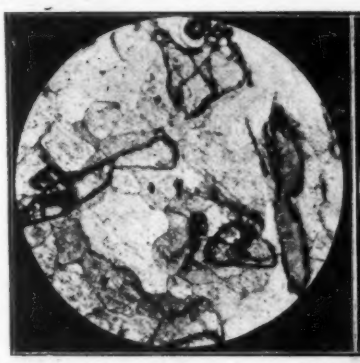


FIG. 5.

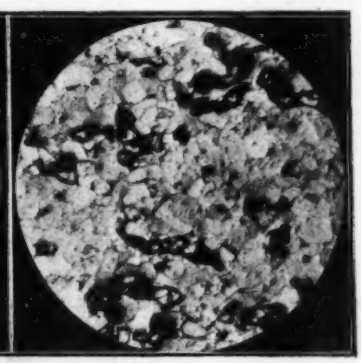


FIG. 6.

The slag is enriched by the entrance of MnO at the cost of the iron oxides FeO Fe_2O_3. Professor Turner's view that in such actions the active oxides FeO Fe_2O_3 are the reducing agents has been taken. They are in the state of least stability and hence in the condition to react with the other unstable compounds present when by superheat their stability is decreased. Possibly at the moment of exchange it is the ferrous oxide which reacts with the Mn_3C in a reversible sense thus :—

$$3FeO + Mn_3C \rightleftarrows 3MnO + Fe_3C.$$

Superheating the oxide FeO in an oxidising atmosphere leads to the formation of Fe_2O_3 (as in the production of "Bull dog slag" by calcining puddling-furnace tap cinder). On the other hand, liquid Fe_2O_3 when in contact with molten Fe alloys is readily converted to FeO providing a reducing or neutral atmosphere is maintained in the working chamber.

Alloying a Metallic Mass underlying a Rich Slag.—In siliconising the white eutectic iron in the hearth of the blast furnace the SiO_2 in the slag interacts with the Fe_3C in the carburised white iron in a reaction of the type :

$$SiO_2 + 2Fe_3C = Fe_2Si + 4Fe + 2CO.$$

The carbide of iron in the eutectic metal is displaced by silicide of iron and pure iron is coincidently set free. CO gas is liberated and the slag is impoverished by the loss of the silica SiO_2. This exchange is affected by the superheating of the slag, the silicate of lime or magnesia therein becoming unstable. The interaction between the SiO_2 and the unstable superheated Fe_3C is thereby promoted as shown.

(c) *Liberation of Occluded Gases.*—When cast-iron is heated considerably above its melting point the occluded gases, which are not inconsiderable in quantity, and consist mainly of CO and H, are set free. An examination of the microstructure of a pig-iron which has been thus heated towards its boiling point reveals particles of silica surrounded by an envelope of ferrite together with flasks of coarse graphite. It would appear that a reaction has taken place in this case between the escaping CO gas and the silicide of iron Fe_2Si, thus :

$$Fe_2Si + 2CO = SiO_2 + 2Fe + 2C.$$

The slaggy particles appearing in the microstructure are probably a silicate of iron formed as per the reaction :

$$Fe_2Si + 3CO = 2FeO.SiO_2 + 3C.$$

In some cases such silicate slag rises to the surface of the metal which has been desiliconised to some extent by gaseous means. Again, sometimes iron oxide particles occur mechanically mixed and distributed throughout the cast-iron or steel mass as a result of over-oxidation or over-blowing in the hearth or bath of the furnace or converter. The effect of superheating such an alloy is to further refine the metal thus :

$$FeO.Fe_2O_3 + 2Fe_2Si = 2SiO_2 + 7Fe,$$
$$\text{or } FeO.Fe_2O_3 + Fe_2Si = 2FeO.SiO_2 + 3\ Fe,$$
$$\text{and } FeO.Fe_2O_3 + 4Fe_3C = 15Fe + 4\ CO.$$

4. The mechanism of refining and alloying through the offices of the slags is shown in Tables I. and II. In the blast furnace a portion of the carbon in the carbide Fe_3C is liberated in the CO gas formed and pure iron is freed to unite with the Si and P as silicide of iron Fe_2Si and phosphide of iron Fe_3P. These actions occur when the slag is superheated.

The automatic adjustment of a typical blast-furnace slag is shown in Fig. 4, where, during the alloying of the iron in the blast-furnace hearth with silicon (the resulting pig-irons having 0 to 3.0 per cent. silicon), the slag composition alters thus :—

	SiO_2.	Al_2O_3.	CaO MgO.	Slag softening temp.
	Per cent.	Per cent.	Per cent.	Deg. C.
Before alloying with Si ..	28.5	20.7	47.1	1435
With 1% Si in pig-iron ..	28.1	21.5	48.9	1440
With 2% Si in pig-iron ..	27.5	21.7	49.7	1440
With 3% Si in pig-iron ..	26.5	22.2	50.3	1445

As the slag adjusts itself during the loss of Si the fusion temperatures of the slag are raised. Hence a higher hearth temperature and resulting slag and metal superheat become necessary as the more highly silicious pig-irons are made.

Table II. illustrates the mechanism of refining action in cupola, open-hearth, and puddling operations. Here the pig-iron being refined is superheated above its melting point, the silicide phosphide and carbide of iron being thereby rendered unstable and react with the similarly unstable slag oxides (in this case the iron oxides). Silica and phosphoric acid escape to the slag and CO gas is liberated. The iron set free by the decomposition of the silicide, phosphide and carbide of iron and that added by deposition from the slag oxides, together with the primary iron crystals in the original pig-iron (if containing less than 4.3 per cent. carbon), yields a refined product more or less free from silicon, phosphorus, manganese and carbon.

6. It is evident from the foregoing that intimate contact between the metals and the slags in smelting, refining, and alloying operations is imperative if successful results are to follow.

In the blast furnace the reduction of the ores must be largely through gaseous (CO) influence. It is not possible for sufficiently uniform carbon (coke) contact with the oxide of iron (Fe_2O_3, etc.) particles to take place. The slag blanket which covers the metal in the hearth of the furnace is agitated by the splashing and penetration of the drops of liquid metal and slag as they descend from the upper portions of the tuyere zone. Hence there is a greater contact between slag and liquid metal than at first appears. The relationship between the area of slag contact and the iron smelted per hour is of practical importance. The ratio

$$\frac{\text{area of slag contact (sq. ft.)}}{\text{iron smelted per hour (tons)}}$$

is, in the case of modern hot-blast furnaces, 15 to 25. In the days of cold-blast furnaces the ratio was as high as 40 sq. ft. of slag contact per ton of iron smelted per hour.

In the foundry cupola the ratio for modern furnaces is 0.7 to 1.0 sq. ft. per ton of iron melted per hour, and in the open-hearth steel-melting furnace the ratio

$$\frac{\text{area of slag contact}}{\text{metal refined per hour}}$$

is 20 to 30. In modern rapid practice in large furnaces the ratio is tending to increase, shallow baths and large area of slag contact being necessary for intensive outputs.

The more viscous and light the slag is the greater is the need for large contact area. During mechanical or natural agitation the heavier slags penetrate the metal surface in direct proportion to their density. In the heavy yet mobile puddling slags the rapidity of the refining action is readily explainable and the low viscosity combined with the continuous hand or mechanical rabbling promotes better contact between the metal and oxide particles.

It can be shown that in the alloying of silicon with iron through contact of the carbide of iron with the silica of the slag in the blast-furnace process the relative surfaces of contact of these two constituents are as 1 : 1.26 approximately, whereas in the decomposition of Fe_2Si in the refining operation of puddling the ratio of contact areas between Fe_2Si and the oxides $FeO.Fe_2O_3$ is as 1 : 1. Hence it follows that more homogenous interactions occur in the latter process. It is interesting to note that the ratio

$$\frac{\text{area of slag contact (sq. ft.)}}{\text{metal refined per hour (tons)}}$$

is about 50, twice that of the open-hearth steel process, the area of contact being sufficiently large to enable efficient washing and rabbling of the metal and slag to be carried out.

7. *The Liquid Crystal Phase.*—Dr. Desch, in his recent invaluable contribution to the Institute of Metals, drew attention to the possible existence of a liquid crystal phase at temperatures higher than the fusion

point of metallic alloys. In the study of ferrous alloys the observed variations in the viscosity of hyper-eutectic alloys when heated above their melting points, the decomposition of the carbide or carbides in carbon iron alloys as influenced by the presence of silicon, phosphorus, etc., resulting in a graphite-bearing viscous state, and the micro examination of such alloys when quenched from the superheated condition, all strengthen the view that above the liquidus curve of the phase diagram there may be a liquid crystal phase. It is difficult to determine such a phase and its temperature limits, but there is much to suggest that liquid iron crystals more or less carbonised and siliconised in ordinary cast-irons and steels do exist, and that their order of iron crystalline deposition is shown in three well-known variations of the open-hearth steel-making processes.

The first stage of the operation in each case is that of melting the charge. In the liquid thus formed are the primary crystals (melted or as liquid crystals) originally present in the pig-iron or steel scrap. The next iron addition to the bath is due to the decomposition of Fe_2Si, the Si entering the slag and liberating the iron of the silicide, coincidently there being added to the liquid mass free iron reduced from the iron oxides of the slag. Manganese carbide is next attacked by the slag oxides and MnO enters the slag, being displaced by pure iron reduced from the iron oxides in the

TABLE I.—*Blast Furnace Alloying Reactions.*

	Superheated unstable constituents.				Resulting alloys in metals.				Constituent ejected from metal.	
	In slag.	Lbs.	In metal.	Lbs.	Compound.	Lbs.	Free.	Lbs.	—	Lbs.
A	SiO_2	60	Fe_3C	360	Fe_2Si	140	Fe	224	CO	56
B	P_2O_5	142	Fe_3C	900	Fe_3P	398	Fe	504	CO	140
C	MnO (1)	213	Fe_3C	180	Mn_3C	177	—	—	FeO	216
D	FeO (2)	216	C	36	—	—	Fe	168	CO	84
					Reactions.					
A	SiO_2	+	$2Fe_3C$	=	Fe_2Si	+	4Fe	+	2CO	—
B	P_2O_5	+	$5Fe_3C$	=	$2Fe_3P$	+	9Fe	+	5CO	—
C	MnO	+	Fe_3C	=	Mn_3C	—	—	+	3FeO	—
D	3FeO	+	3C	=	—	—	3Fe	+	3CO	—

TABLE II —*Open-Hearth Puddling and Cupola Refining Reactions.*

	Superheated unstable constituents.				Result of refining new constituents added.				Gases ejected.	
	In slag.	Lbs.	In metal.	Lbs.	To slag.	Lbs.	To metal.	Lbs.	—..	Lbs.
A	$FeO.Fe_2O_3$	232	Fe_2Si	280	SiO_2	120	Fe	392	—	—
B	$FeO.Fe_2O_3$	232	Mn_3C	177	MnO	213	Fe	168	CO	28
C ..	$FeO.Fe_2O_3$	464	Fe_3P	398	P_2O_5	142	Fe	504	—	—
					FeO	216				
					Reactions					
A	$FeO.Fe_2O_3$	+	$2Fe_2Si$	=	SiO_2	+	7Fe	—	—	—
B	$FeO.Fe_2O_3$	+	Mn_3C	=	3MnO	+	3Fe	+	CO	—
C	$2FeO.Fe_2O_3$	+	$2Fe_3P$	=	P_2O_5	+	9Fe	+	3FeO	—

carbonisation and siliconisation are effected more rapidly as the temperatures approach the purely liquid phase.

Taking the fusion points of iron and iron carbide Fe_3C as 1,500 deg. C. and 1,850 deg. C. respectively, it might be found that a line drawn between the two (possibly not a straight line but a drooping curve one) would be the frontier line between the purely liquid and the liquid crystal phases. In such a case the primary nucleii for crystal growth would occur within the liquid crystal phase and would not depend upon the freezing action in the now recognised solidus phase. Thus graphite may be precipitated in the liquid phase and act as the nucleus for the primary liquid crystals. Similarly silico-ferrite crystals may commence to form from the same or a higher temperature in the liquid phase and start a secondary ferrite liquid crystallisation.

It is in such considerations that the difference between crucible (a furnace with walls superheated above the temperature of the liquid crystal phase) melting and cold-hearth melting appears. Just as the steam bubbles in a boiler rise most strongly from the zones next to the heating surfaces, so the occluded gases and convection currents within a molten metal in a crucible rise most powerfully from the zones next to the heated walls. These details may have much to do with the fineness of crystalline structure in the final cast metal and with the homogeneity or otherwise of such structure. The fineness of such structure is related to the crystal boundary question, and to the freedom from gaseous or refining oxide and slaggy inclusions within such boundaries.

8. It is instructive in this connection to trace the successive series of iron (liquid crystalline) deposition in the refining processes. In Table III. the possible slag. After this comes the carbon elimination, the carbide Fe_3C on decomposition yielding its Fe to the bath and simultaneously adding pure iron reduced from the iron oxides in the slag. Finally when iron ore (Fe_2O_3) in excess of purely refining requirements is added to the slag further iron is reduced and makes the final contribution to the mass of refined metal. The analyses and estimates given in the table are only approximate, but are believed to offer a comparative view of the order of iron crystallisation during refining in the three types of steel-making. Whether the iron increments are actually liquid crystals is as yet open to question.

TABLE III. *Analysis of Materials.*

Materials.	C.	Si	Mn.	Fe.	Fe_2O_3.	SiO_2.	S. & P.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Pig-iron ..	3.8	1.5	0.8	93.9	—	—	not estimtd.
Steel scrap ..	0.2	0.1	0.7	99.0	—	—	—
Ore ..	—	—	—	—	60.6	10.0	—

Pig and Ore Process—charge 75 per cent. pig, 25 per cent. ore.

(1) Primary Fe crystals in pig-iron .. = 30.5 initially present in pig-iron } A

(2) Iron crystals from Fe_2Si decomposition = 4.3 refining of silico ferrite

Iron crystals from slag reduction .. = 3.3

(3) Iron crystals from Mn_3C decomposition = 0.7 refining of eutectic } B

(4) Iron crystals from Fe_3C decomposition = 40 0 „

Iron crystals from slag reduction .. = 9.6 „

(5) Iron crystals from ore reduction .. = 11.6 alloying by iron reduced from ore } C

Pig and Scrap Process—charge 50 per cent. pig, 50 per cent. steel scrap

	Per cent	
(1) Primary Fe crystals in pig-iron	= 18.5	A
(2) Primary crystals in scrap iron	= 44.0	A
(3) Crystals from Fe_2Si decomposition	= 2.9	B
Crystals from slag reduction	= 1.9	B
(4) Crystals from Mn_3C decomposition	= 1.1	B
(5) Crystals from Fe_3C decomposition	= 25.6	B
Crystals from slag reduction	= 6.0	B

Pig, Scrap and Ore Process—charge ⅓ of each.

	Per cent.	
(1) Primary Fe crystals in pig-iron	= 14 6	A
(2) Primary Fe crystals in scrap iron	= 34 5	A
(3) Crystals from Fe_2Si decomposition	= 2.4	B
Crystals from slag reduction	= 1.6	B
(4) Crystals from Mn_3C decomposition	= 0.8	B
(5) Crystals from Fe_3C decomposition	= 20.00	B
Crystals from slag reduction	= 0.40	B
(6) Crystals from ore refining	= 20.2	C

9. *Refined Iron Structures and Superheating Conditions.*—In the U.S.A., Mr. J. E. Johnson, Jun., the well-known blast-furnace expert, has produced a cast-iron which approximates in character to the finest of charcoal cold-blast iron such as is made in Sweden. By adding a cast-iron which has been partly refined in a Bessemer converter to an ordinary foundry iron molten from the blast furnace the following actions occur.

The Bessemerised metal low in carbon content and containing considerable quantities of occluded gases and oxide particles is much higher in temperature than the blast-furnace metal to which it is added. The superheating action on the latter metal lays open the unstable carbon and silicon as carbide and silicide of iron to a secondary refining action. Some of the graphite is probably oxidised, and iron oxide from the Bessemer metal becomes reduced within the mass. The result is a lower-carbon iron with smaller nucleii of graphite than is found in hot-blast pig-irons.

The relative action of slow and rapid refining as typified in the production of practically carbonless iron in the puddling and open-hearth furnaces is well illustrated in the two micro-photographs, Figs. 5 and 6 (100 diameters, reduced in reproduction to about 65 diameters). Here the same raw materials were used in the open-hearth and puddling operations, the resulting refined irons being of similar analysis. The two irons were similarly reheated, piled and rolled. The difference in the size of the ferrite crystals is very pronounced, the puddled iron having much the coarser structure. The open-hearth iron, melted and refined under high superheat conditions unassisted by artificial rabbling and agitation, has a finer crystallisation than the puddled iron, which is refined at lower temperatures. This latter action, carried out in a hearth which is itself composed of active reducing oxides, must obviously tend to a coalescence and welding of adjacent iron grains or crystals, which is impossible in a bath where the refining action proceeds by way of contact only with a superincumbent slag of low specific gravity and high viscosity. It goes without saying that the question of crystalline metallic structure is inseparably connected with the slag functions. Micrographic analysis cannot reveal the true character of the boundary films, the process of polishing the slag inclusions being altogether unsatisfactory when it is desired to reveal the characteristic structures at high powers of magnification. It would appear, therefore, to be of increasing importance to study the crystalline boundary problem in the light of the foregoing conclusions, bearing in mind the facts that the crystals or crystallites begin to grow in a liquid carrying oxides, slaggy, gaseous, or metallic.

These oxides, during their own decomposition, may form secondary crystals, or, in their passage to the slag covering, become entrapped as films within the contracting crystal boundaries.

A GAS-BURNER for heating boilers, furnace stoves, etc., with coke-oven or blast-furnace gas has been patented by Mr. F. D. Harper, manager of the Allerdale Coal Company's by-product works, and a company has been formed to put it on the market.

Acids for Pickling.

In a recent paper before the American Drop Forge Association, Mr. J. H. Snyder remarked that acids used for pickling are sulphuric, muriatic, hydrochloric or hydrofluoric. Sulphuric acid 60 deg. and 66 deg. Baume is most generally used in America, principally on account of the ease of transporting large quantities in tank cars and its comparatively low cost. Many companies change completely the sulphuric acid solution every 24 hours in the following manner:—When the work is commenced in the morning a solution, say, 8 per cent. sulphuric acid by volume, is put in the vat; the proper amount of water is mixed with the acid and throughout the day sufficient acid is added to keep the necessary strength.

Where the material to be pickled is covered with oil or grease, potash solutions are used to clean the surfaces. Potash is very expensive at the present time and a substitute known as Wyandotte cleanser is used. It is claimed that as high as 50 per cent. sulphuric acid is saved in the proper cleaning of the materials preparatory to the acid bath.

The amount of sulphuric acid to a ton of steel pickled varies with the character of material and with the chemical analysis of the acid, and ranges from 50 lbs. to 200 lbs. The temperature of the sulphuric acid solution should be kept as near the boiling point as possible. In the various plants throughout the country the temperature varies from 75 deg. Fah. to 212 deg. Fah.

Amounts of Sulphuric Acid Required for Pickling.

Kind of Material.	Per cent. of acid by volume.	Average pickling time in minutes.	Method.
Tinplate	2 to 10	6 to 10	machine
	10 to 20	10 to 20	hand
Sheets	4 to 10	8 to 12	machine
	10 to 18	10 to 20	hand
Wire	6 to 12	15 to 30	machine
	10 to 20	25 to 50	hand
Pipe	6 to 8	10 to 15	machine
	8 to 20	20 to 25	hand
Cold rolled	8 to 10	12 to 15	machine
Steel	10 to 15	20 to 25	hand
Stampings	8 to 12	15 to 18	machine
Forgings	8 to 10	15 to 18	machine
	15 to 20	20 to 30	hand
Enamelware	10 to 15	15 to 20	machine
Brass	10 to 15	5 to 8	hand
Alloy forgings ..	8 to 10	20 to 30	machine
	8 to 10	20 to 45	hand

The temperature of water vats is a problem which everyone must work out for himself, being governed entirely by the kind of material to be washed. Certain kinds of material require cold water while others require it just as hot as it is possible to make it. For instance, enamelled ware is immersed in cold water, while sheets of heavy gauges are rinsed in very hot water and allowed to dry from the heat generated.

IN the House of Commons last month, Major H. Terrell asked the Under-Secretary of State for War whether he was aware that several engineering apprentices had been drafted into Infantry regiments? Mr. Macpherson replied that apprentices in the engineering trades, if they passed a trade test, were posted to a technical corps, among which were included the Royal Engineers and Royal Flying Corps. He was not aware that there had been any departure from that practice, and asked for the regimental numbers, names, and units of the men to whom Major Terrell referred.

Electric Steel Furnaces, with Special Reference to the Greaves-Etchells Type.

By E. Kilburn Scott, M.I.E.E.

Since the war began, one of the most striking developments of the steel industry of Great Britain has been the rapid increase in the number of electric steel furnaces; so successful have they been that the prejudice against this type of furnace is rapidly disappearing, and the change will probably rank as the most radical one since the time of Bessemer. Amongst factors which have helped to bring the electric furnace into favour are the following:—

(*a*) The war demand for special tool steel for tools, dies, gauges, etc. (*b*) The demand for

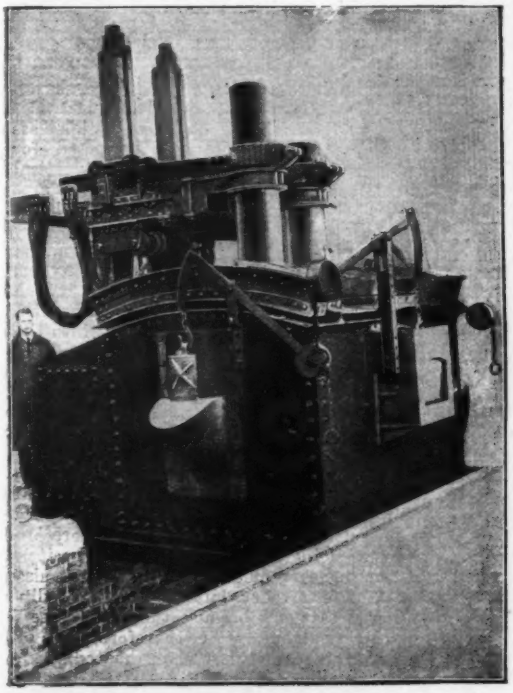


FIG. 1.—THREE-TON GREAVES-ETCHELLS FURNACE.

chrome and other special alloy steels for aircraft tubing, rustless steel, etc. (*c*) The difficulty in obtaining Swedish iron, which, besides being scarce, is extremely expensive. (*d*) The difficulty in obtaining skilled labour to work the crucible steel process. (*e*) The necessity of profitably using turnings, millings, ends of tubes, bars, and other scrap steel. (*f*) The ease with which high-class steel can be made from second-grade materials in electric furnaces.

Certain electric supply authorities—as, for example, those at Sheffield, Newcastle, Rotherham and Luton—have done much to encourage electric furnace loads by reducing charges for energy, and by moderating the requirements as regards power factor, the unbalancing of phases, etc. The foresight of the city electrical engineer at Sheffield is especially commendable in preparing for an electric furnace load.

The following are some of the advantages of treating steel in electric furnaces over the older methods by crucibles, and the Bessemer and open-hearth furnaces:—(1) The charge is not in contact with the products of combustion of carbonaceous fuel. (2) The charge is under the absolute control of the operator; the conditions can be made oxidising, neutral and reducing as required. (3) The melting loss is an absolute minimum, as compared with 7 to 15 per cent. in other processes. (4) The charge can be made up entirely of very cheap base material such as turnings, borings, millings, light scrap or large rough scrap, and can be easily melted and refined to a steel low in impurities and of exceptional quality. (5) The temperature can be controlled almost instantly over a very wide range, which allows a wider range of chemical refinement than is possible by other means. (6) Scrap containing valuable elements such as nickel, chromium, vanadium and tungsten, can be melted without loss of these elements. (7) The steel produced is purer, more free from dissolved gases, slag fibre, etc., and therefore has much better physical properties than that produced by any other method. (8) Steels containing any desired percentage of carbon, and even carbon-free, can be produced.

For the manufacture of high-quality steel castings the electric furnace may be called ideal. The superiority of electric steel castings over those made by other processes has been proved by the extremely severe conditions to which these castings have been subjected under specialised war conditions. The castings produced can be finished off dead mild and a 1-in. square bar can be bent double as cast, no expensive annealing operations being necessary. The carbon contents usually vary between 0.2 per cent. and 0.25 per cent., while the sulphur and phosphorus are each reduced below 0.015 per cent. and manganese and silicon are adjusted to suit the work. The tensile properties of ordinary electric cast steel are:—Maximum tensile strength, 35 tons per sq. in.; yield point, 25 tons per sq. in.; reduction of area, 50 per cent.; elongation, 30 per cent.; while the maximum tensile stress can be readily increased to even 100 tons per sq. in. by the introduction of special elements such as nickel, chromium and vanadium.

Many works that sell their steel swarf and scrap, cast-iron borings, etc., at nominal prices and purchase all their steel castings, could very profitably install an electric furnace and make their own castings from the scrap. The charge can be made up entirely of scrap and turnings; no expensive raw materials are necessary. The melting loss is almost negligible, while, as already noted, in other processes it is from 7 per cent. to 15 per cent.

Steel from the electric furnace is finished off under a reducing atmosphere of carbonic oxide and a slag out of which the metallic oxides have been reduced, and is singularly free from blowholes when properly cast. This is due to the elimination of the gases that molten steel usually holds in solution; the ease with which the steel can be poured into small and intricate castings, flowing smoothly

like milk and setting perfectly quietly in the moulds, is largely due to its purity.

For small light castings furnaces of not more than 30 cwts capacity are recommended; steel of low carbon content has a high melting point and must be cast at a very high temperature, and though this is easily obtainable in the furnace, difficulties occur in handling large quantities of such hot metal in ladles if a large number of castings are to be made. For small mild-steel castings —many of which have proved a good substitute for malleable iron castings—smaller furnaces are recommended, and several firms have installed furnaces of 10 cwts. capacity to melt steel for small engine parts of motor cycles and motor cars instead of using stampings.

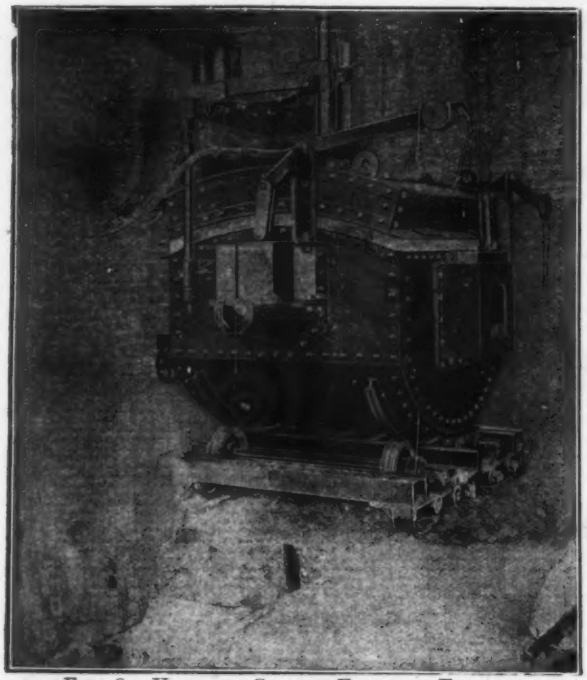


FIG. 2.—HALF-TON GREAVES-ETCHELLS FURNACE.

Where large quantities of good-quality steel are required the "hot-metal process," as it is called, combines cheapness and quality. It has been adopted very extensively in the United States. The metal is first heated in a basic-lined tilting open-hearth furnace of large capacity, and is then run into a number of electric furnaces for final refining and addition of alloys. The process is continuous, and as the energy for first melting of the steel is obtained direct from fuel, the amount of electrical energy is only that required to maintain the temperature during refining and the assimilating of the alloys. Steel so produced commands high prices.

Electric furnaces are successfully used for the melting of ferro-alloys for open-hearth and Bessemer plants, as it is found much more economical to make alloy additions in the molten form.

Types of Furnace.

As the earlier furnaces were for small outputs, single-phase alternating current was used, and to obtain a balance on a multiphase supply several furnaces had to be worked together. Multiphase furnaces are better than single-phase furnaces, because for a given output of steel one such furnace is cheaper, takes up less room, and requires less attention than several single-phase furnaces. With single-phase, if one arc fails the circuit is broken and the load falls to zero. This is liable to happen during the melting-down period when the pieces of scrap metal change position under the electrodes.

Two distinct types of electric furnaces are used for steel manufacture:—(1) The Induction Type, which acts on the principle of an alternating-current transformer, the metal being melted by having very heavy currents induced in it by a single-phase or three-phase supply. Although these furnaces are used to a considerable extent abroad, they are not favoured in this country, and so will not be discussed further in this article. (2) The Arc Type of furnace, which has electrodes of carbon or graphite, and the metal is melted by arcs formed between the electrodes and the charge or between the electrodes themselves. Arc furnaces may work with single-phase or two or three phases. Some arc furnaces have all the electrodes above the bath of metal, one of this class being the Héroult. As arranged for three-phase supply it has three vertical electrodes through the roof and the arcs are between each electrode and the bath, so that the molten metal forms part of the electrical circuit. Two furnaces, namely, the Girod and the Snyder, employ water-cooled steel studs, which pass right through the bottom or hearth. As the ends of the studs project into the metal of the charge they burn away and have to be renewed at intervals. This form is also not good practice, because of the danger of the metal finding its way through the hearth; and the liability of trouble with water connections.

It will be noted that in all the above-named furnaces the refractory material of the hearth does not require to carry current. The material may be therefore either acid (silica) or basic (magnesite). The furnaces mentioned below have also bottom electrodes, but come under a different category because the hearth itself conducts electric current. It is therefore made of magnesite material, as this, when heated, is a fairly good conductor.

A furnace of this class is that of Electro-Metals, Limited, which was invented by Gronwall. It works with two phases and has two electrodes above the bath, whilst a third electrode below the hearth acts as a common neutral for the two phases.

Another furnace which has met with considerable success is that of Greaves-Etchells, more than 30 having been installed or put under construction since January 1, 1916. As this is an all-British production, both in inception and manufacture, a detailed description will be of interest, supplementing that given in our columns recently. It is designed to operate on a three- (or two-) phase supply, and has two of the phases connected to electrodes above the bath, the third phase being connected to a copper plate below the electrically-conductive hearth of magnesite. The furnace body consists of a rectangular tank made of riveted boiler plating, and strengthened by angle sec-

tions. The bottom is dished, and has two steel rails of Vignoles section rivetted to it. These rest on grooved steel rollers, and the whole furnace with its electrodes, etc., can be tilted backwards and forwards by means of a screw and gear wheels. In the small furnace the tilting is effected by a hand-wheel, and in the larger sizes by means of an electric motor. Each electrode is secured in a

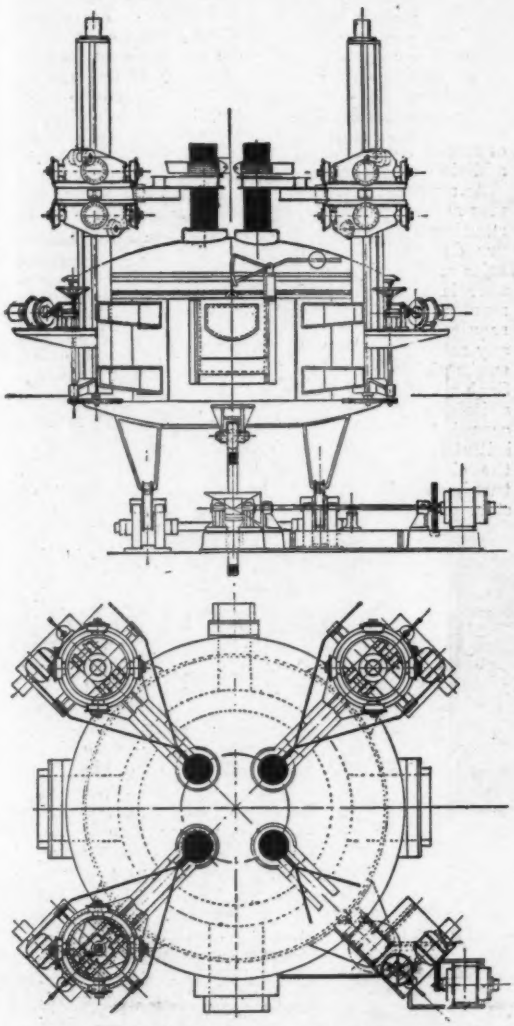


FIG. 3.—PLAN AND ELEVATION OF 10-TON FURNACE.

holder made of bronze or steel, and each holder is attached to, but insulated from, a steel jib projecting from a wheeled carriage. The carriage travels up and down a vertical mast, which is made of two channel sections bolted on to the side of the body. In small furnaces, the electrodes are regulated by a hand-wheel, and in large furnaces by a motor through single-reduction gearing. The roof is made of silica bricks, as these are fairly good insulators. They are set in a steel framing which rests on the silica brick walls projecting above the steel body of the furnace. The roof is domed and brought as low as possible so as to reduce the wasting away of the electrodes by action of the gases. A roof will last about 100 heats, and a duplicate one is provided with each furnace, so that the steel melting can be carried on, except for the short time taken to change the roof.

In order to obtain an even temperature through the bath of molten metal in the electric furnace it was realised that heat must be applied below as well as above the bath, and in order to effect this the hearth of the furnace is specially constructed. Above 12 per cent. of the total energy of the Greaves-Etchells furnace is used in the hearth, and the "bottom heating" which results is found to be of great advantage in melting down alloys. The heavier alloys, chrome, tungsten, vanadium, and nickel, sink to the bottom of the bath, and if there is no bottom heating are apt to remain for a considerable time in a semi-fluid state. The hearth lining is never less than 20 in. thick, and is constructed mainly of dolomite and magnesite, in such a manner that the electrical resistance is high at the inside of the bath in proximity to the charge, and decreases rapidly to a negligible quantity at the outside. The current flowing through the hearth generates a considerable amount of heat immediately below the liquid in the most efficient manner possible, while the electric arcs arranged over the bath maintain the slag and surface at the desired temperature. The effect of this bottom heating is to cause convection currents in the molten metal, which ensure a constant circulation, and a uniform product. The outside of the furnace bottom remains cold, little or no heat being lost in this direction.

This system of connection at first sight would appear to cause an out-of-balance load on the primary supply, but the system of transformer ratios is arranged to give a perfect balance when the upper electrodes are in equal adjustment. The high-tension electric supply is transformed by means of a delta-star system of connection to low tension, the transformer house being as near as possible to the furnace in order to avoid heavy copper costs and energy losses in the low-tension connections.

The equipment has to be designed to withstand short-circuiting of the electrodes, as this occurs in all furnaces during the melting process when pieces of metal fall against the electrodes. The method usually adopted by furnace builders to provide against this is the introduction of considerable reactance in the electrical system, but unfortunately this reduces considerably the energy available in the furnace; it increases the energy losses, and also is very objectionable to the supply authorities. The Greaves-Etchells system of transformer connections is such that the short-circuit current of one electrode must traverse two transformers in series and in different phase, which automatically lowers the power factor momentarily, and has a strong buffer effect; the fact that there is always a permanent resistance in the path of the current through the hearth also limits considerably the effects of short-circuits. The combination of these factors provides the most effective means yet devised for protecting the supply system from shock, while allowing a high power factor to be obtained on normal load.

In all electric steel furnaces the metal is poured by tilting the furnace, and when this is effected by mounting the furnace on rockers, the end of the spout not only moves downwards, but also away from the ladle. Clearly the only way to keep

the spout in one position would be to rotate the furnace round it; but this is out of the question because it would mean lifting the furnace bodily and take too much power. A 10-ton furnace, for example, may weigh as much as 90 tons. The makers of the Greaves-Etchells furnace have compromised by arranging for the spout to descend in a vertical line so that the furnaceman and craneman have merely to see that the ladle is lowered while the metal is running out. This is effected by the system of compensating rollers shown in Fig. 4. The furnace is carried on two sets of rollers, and as it is tilted it causes the top rollers to rotate the bottom rollers, and this moves the furnace bodily forward. The wheels are so proportioned that the movement forward is just the right amount to keep the end of the spout vertical, as it descends.

Greaves-Etchells furnaces are made in the following sizes:—

Charge.	Kilo-volt amperes.	Number of top electrodes.	Diameter of graphite electrodes.
Tons.			Inches.
½	260	2	4
1½	520	2	7
3	800	2	8
6	1,300	4	8
9	2,000	4	9
12	2,600	4	10

For the manufacture of high-speed steels or special alloy steels, a ½-ton or 1½-ton furnace is usually adopted, and the former can finish a charge from cold material and alloys in 2 to 2½ hours, with an energy consumption of 400 units. To make up a charge from scrap, it is usual to place steel turnings and millings on the hearth, then pieces of bar and rail ends, tube ends, and finally large pieces of steel. The interstices between the large pieces are filled with turnings, etc., and some iron ore may be added. The amount of iron ore depends on the amount of iron oxide present in the form of rust on the scrap. As the charge is melted, a slag of lime and fluorspar is made in order to eliminate the phosphorus, as phosphate of lime. After this phosphate slag has been skimmed off, a new slag is made of best Buxton lime, fluorspar, and white sand, in the proportions of 30, 10, and 5. When this has fluxed, a small quantity of finely-powdered anthracite coal is spread on the slag, and this is continued until the slag is deoxidised. The steel is thus finished off under an atmosphere of carbonic oxide, and a slag out of which the metallic oxides have been reduced. When entirely deoxidised a sample of slag falls to a fine white powder as it cools. Deoxidisation of the slag results in deoxidisation of the steel, through the constant reduction of silicon from the slag, and it may be hastened by addition of small quantities of ferro-silicon.

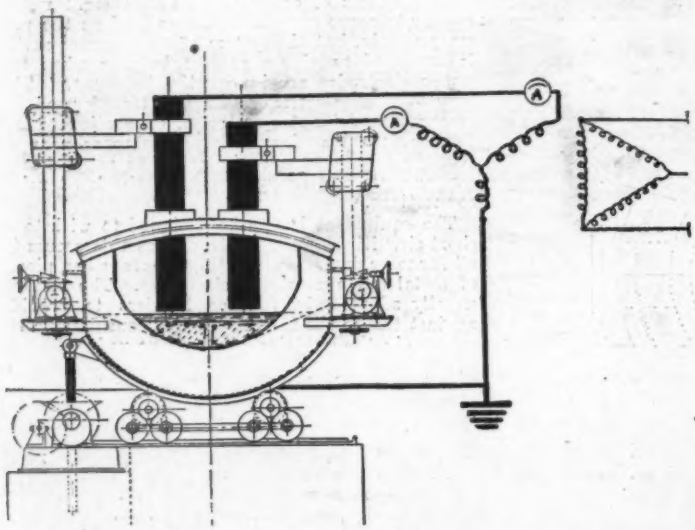


FIG. 4.—SECTION OF 6-TON GREAVES-ETCHELLS FURNACE, SHOWING CIRCULATION OF METAL AS IN BOTTOM HEATING.

As a comparison with the crucible steel process it may safely be stated that a 10-cwt. electric furnace running a charge every 2½ hours, or say 9 charges per day, will do as much as 36 crucible furnace holes each having two 56-lb. pots. The electric furnace is operated by one skilled man, one unskilled man, and one ammeter boy, whereas the crucibles require 15 men, most of whom are skilled, or at any rate classed as indispensable. At two Sheffield works girls are employed to regulate the electrodes. Such an electric furnace with its transformers and switchgear will occupy about a quarter of the space occupied by, and can be installed at about half the initial cost of, the crucible plant. The charge of the electric furnace can be made entirely from turnings, millings, etc., whereas in the crucible steel process only a very limited quantity of turnings, etc., can be used.

Owing to the low heat efficiency and high cost of labour, crucible steel is much more expensive to manufacture. The cost of renewing crucibles is considerably higher than the renewal of an electric furnace for the same output. Already several steel works have shut down their crucible plant after installing electric furnaces.

The introduction of the Bessemer and open-hearth process of making steel left crucible steelmakers indifferent, owing to the fact that these methods were employed for making ordinary kinds of steel in great quantity for structures, rails, etc. The coming of the electric furnace is a different proposition, as it competes directly and successfully in the special field that the crucible steel process has held so long. The latter process has been largely responsible for waste of the nation's resources by reason of the coke used being made in beehive ovens, this quality of coke being necessary for the process. The introduction of the electric furnace should help to stop this waste in the future.

In conclusion it may be mentioned that very soon there will be 50 electric furnaces at work in the Sheffield district, and the output of steel from them will be at the rate of over 200,000 tons per annum.

The Messroom and Workmen's Club at Halesowen Steelworks.

Not the least important development arising from the high pressure at which almost every class of artisan has been called upon to work is the tendency on the part of the manufacturer to more closely study the comfort and convenience of the workers. It may be said that this is a social problem, but such a statement is only true to an extent, as the commercial outlook must obviously be more or less affected by working conditions. In most instances, however, it required a period of exceptional demand upon the energies of the men before the manufacturers were wholly able to appreciate the important advantages arising from the provision of suitable messrooms for workmen and staff.

FIG. 1.—MESSROOM AND WORKMEN'S CLUB AT HALESOWEN STEELWORKS; VIEW IN MEN'S DINING ROOM.

The messroom at the Halesowen Steelworks is rather more wide in its scope than is usually the case. The building, which we illustrate in plan on page 475, occupies two floors and provides messroom accommodation for upwards of 900 men and girls. As will be seen from the plan, the kitchen (Fig. 2) is conveniently arranged on the lower floor and occupies a central position, dividing the male from the female portion. Here the canteen provides dinners at very moderate charges, or alternatively the men may bring their own food, which is cooked free of charge.

Beyond the respective dining rooms are locker rooms and, leading from these, well-appointed lavatories, as also shower-bath and ordinary bath accommodation, whilst the usual provision is made for stores and offices for the canteen manageress and staff.

The first floor is fitted up as a club room (Fig. 3) with a piano and movable platform for concerts, etc. On the first floor also is the staff dining room, bath room, etc., and the general manager's private room.

The building was built and equipped at the expense of the Halesowen Company, and then handed over to the men, who formed a committee of management working in conjunction with the works management, and arranged the catering so as to make the messroom and club self-supporting.

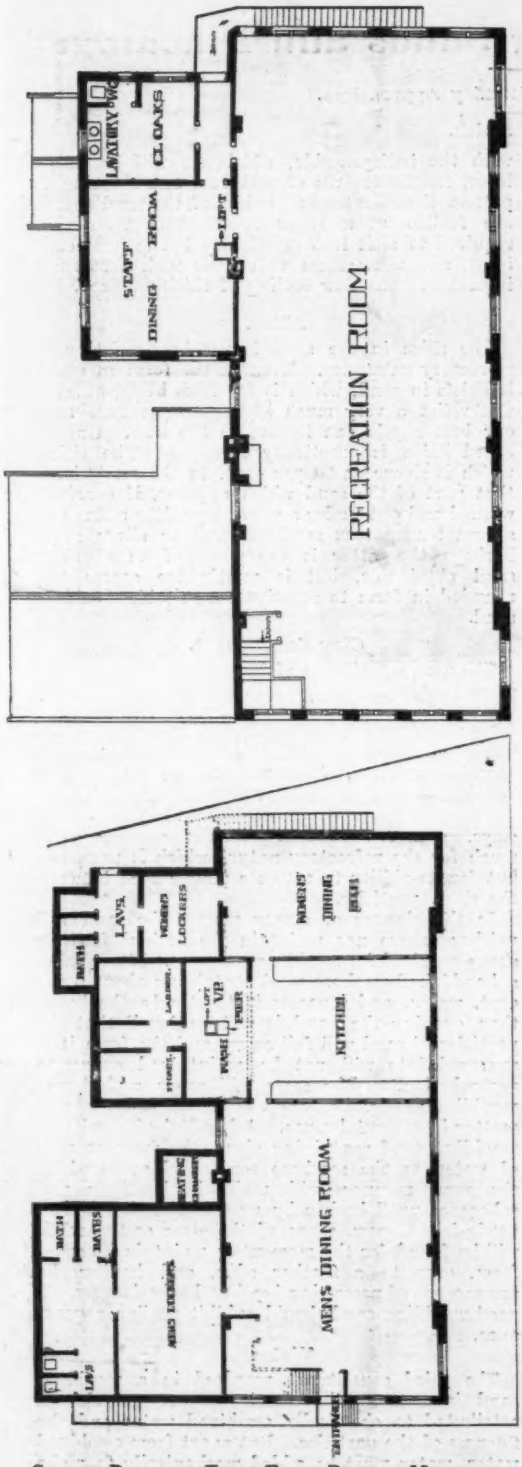
Another interesting innovation at the Halesowen Steelworks for which the managing director, Mr. H. C. Dickson, has been responsible, is the method of adjusting internal difficulties, such adjustments being made by a committee of seven men elected by the workmen. This committee acts in conjunction with the management to adjust all matters of dispute, an arrangement which has the wholehearted support of all the men engaged.

Evidence of the excellent relations existing between the management and the workmen was furnished when the messroom was formally opened

FIG. 2.—MESSROOM AND WORKMEN'S CLUB AT HALESOWEN STEELWORKS; VIEW IN KITCHEN.

and the workmen and staff were entertained at dinner, advantage being taken of the occasion to present Mr. Dickson with a handsome and beautifully fitted dressing-case, and Mrs. Dickson with a bouquet and flower-holder, the last arranged for conversion into a vase and suitably engraved.

FIG. 3.—MESSROOM AND WORKMEN'S CLUB AT HALESOWEN STEELWORKS; VIEW IN CLUB ROOM.



GROUND PLAN AND FIRST FLOOR PLAN OF MESSROOM AND WORKMEN'S CLUB AT HALESOWEN STEELWORKS.

Metallurgical Developments in the Midlands.

In the course of a review of the position of metallurgy in the Midlands, given by PROFESSOR T. TURNER (Birmingham University) at the annual meeting of the Society of Chemical Industry, held recently in Birmingham, he said that not only had instruction and research been interfered with by the war, but the energies of the whole district had been diverted and intensified, and changes had been introduced, the results of which would be seen in later years. The population, of which Birmingham was the business centre, was nearly equal to that of half Belgium. Closely associated with the production of coal and iron in that district was the supply of refractories, and the manufacture of copper, brass, nickel, and other metallurgical materials. The production of iron and steel in the Staffordshire district was limited by the moderate supplies of ore in an inland centre. The output, however, was by no means negligible, and was equal to that reached by the whole of the United Kingdom a century ago. The basic process of steel manufacture was generally followed, and the open-hearth furnace was taking the lead there as in other centres of the steel trade. The wrought-iron trade, though much smaller in value than in its palmy days, still flourished, and all the local works had been fully employed at remunerative prices. The blast furnaces produced foundry, forge and basic pig-irons; the maximum output had been maintained, and it was proposed to put additional furnaces in blast. In the brass and copper industries there had been unprecedented activity. Although no new scientific discoveries had to be recorded, many improvements had been introduced into works practice. Incidentally, reference might be made to the extended use of town gas for melting purposes, with resulting increase of speed and economy. Tilting furnaces were now much more used than formerly. The local nickel industry had been taxed to its utmost capacity. Not only had there been an unprecedented demand for cupro-nickel, but the nickel-silver trade had been by no means idle; whilst there had been a demand for pure nickel goods such as were formerly imported from the Continent. In no direction had there been greater extension locally than in the aluminium industry. There were several large aluminium foundries in Birmingham, and the output of only one of these was equal to that of the whole world a dozen years ago. The product had been largely used in connection with munitions of war, as in certain parts of shells, aeroplane construction, and many other directions where strength and lightness were desired. The metal was now generally melted by means of town gas as fuel. The melting was performed either in graphite crucibles, or, very commonly, in cast-iron pots, which were preferably protected by a wash of inert material. Recently, special attention had been drawn to the production of malleable cast-iron, an industry which had long been associated with Walsall, Birmingham, and the immediate district. There were at present some ninety firms engaged in this local trade, and many of these conducted their business on a relatively small scale. The raw material employed was obtained from pure hematite iron, as it was usually considered to be important to have metal low in phosphorus and manganese. The demand for specially pure irons for other purposes had caused attention to be directed to the question of how far other materials could be employed for malleable cast-iron. It was known that good material could be produced even with 0.25 per cent. of sulphur or phosphorus present, though the details of the annealing process had to be modified somewhat. The problem of introducing an iron of a somewhat different composition without disorganising the work of the smaller manufacturers, who depended largely upon old established methods of working, was a difficult one. No doubt in time the larger firms would be forced in this, as in other manufactures, to adopt scientific methods, including chemical analysis and accurate temperature measurements.

Moulding Sands, Facing Sands and Blackings.

Notes for Ironfoundry Apprentices.

By S. G. Smith.

Apprentices in the foundry require to become acquainted with the materials which form the moulds into which the molten iron is poured. These materials include such as red moulding sand, yellow moulding sand, common clay, blacking, oil, seashore sand, and various mould-facing sands. As regards the average young moulder, and also the moulder of many years' experience, the composition and properties of the sands which form the mould and cores never concern their minds. Perhaps it is not absolutely necessary that they should do, because it is becoming a common practice for the sands purchased to be prepared and mixed mechanically and otherwise in the foundry ready for use; but this cannot be done economically haphazard. Someone in a responsible position having some knowledge of the nature of the sand and the requirements for various kinds of work must be at the back to give instructions regarding mixture and manipulation, because in a general foundry the mixing and grinding of facing sand, core sand, and loam differs widely according to the kinds of work, and also the nature of the sand differs according to the district in which it is quarried, not so much apparently in composition as in actual behaviour under similar conditions.

The following remarks are intended to give merely general enlightenment upon the subject of moulding sands, their composition, what is required, and what is not required; also the additions to facing sands, loam, etc., such as opening material, coal dust, blacking, etc. Explanations will be given as to why these are added to the ordinary moulding sand. A sand fulfilling all the requirements of the foundry has not yet been naturally quarried, hence the additions and manipulations necessary in preparation of both sand and moulds. Every ironmoulder should know how to mix his own facing sand, if necessary.

Most common moulding sands are either red, terra-cotta, or yellow. The following is an aproximate composition of a common moulding sand regardless of colour. Perhaps the form in which I have shown it is uncommon, but should be interesting to the young foundry student :—

Composition.	Per cent.	Formulæ, etc.	
Silica	80.0	SiO_2	Silicon dioxide
Alumina	9.0	Al_2O_3	Aluminium oxide
Ferric oxide	3.50	FeO_3	Iron
Lime	0.50	$CaCO_3$	Calcium carbonate
Magnesia	2.25	MgO	Magnesium oxide
Soda	1.0	Na_2CO_3	
Titanic oxide	0.20	TiO_2	Titanic acid
Water	2.0	H_2O	(Combined)
Moisture	0.50	H_2O	Air and water

In addition to the above, there may be present 2 to 3 per cent. organic matter. Clay, mica, or colloids are not directly shown in the above, but they exist in more or less quantities in most moulding sands in some form hidden in the composition of the above.

The chief requirements for an iron-foundry moulding sands are silica, clay and water. If it were possible to quarry a sand containing the right proportions of these three elements, all the others could with advantage be dispensed with; but with a common moulding sand we must take the dispensable with the indispensable, which, as will be shown later, entails the use of coal dust and blacking to protect the silicates and oxides of the sand (which are fusible at a lower temperature than that required to melt iron sufficiently hot to pour castings), and allow them to endure such heat as is involved in the slow cooling of thick castings.

Silica.

The silica in the sand is the heat-resisting or refractory substance. Even in the form in which it exists in sand, which is far from being pure, it will resist a very much higher temperature than our best cupola can impart to the iron. Uncombined silica is practically infusible. The silica, which is shown as 80 per cent. in the analysis, is that part of the sand which appears, if carefully washed and put under a microscope, like a fine and almost transparent seashore sand or silver sand. Perhaps the latter is the purest form of silica sand obtainable, but is mostly too coarse and rounded in form to constitute a suitable moulding sand.

Clay Constituent.

The next constituent of importance necessary for a moulding sand is clay. Of clay itself very meagre knowledge is to be obtained, except that it is formed by the decomposition of felspars. These are rocks such as granite, etc. Clay probably contains colloids, *i.e.*, minerals existing in a colloidal or jelly condition.

The mineral kaolin is considered the basis of all clays. Clay is needed in a moulding sand, not so much for the refractory nature which it possesses, but for its ability to act as a plastic bond between the silica particles.

In the absence of clayey matter the sand will neither cohere nor maintain the desired form or shape required for moulding purposes. If one takes a handful of seashore sand containing about 6 per cent. water, and squeezes it tightly in the hand, then opening the hand, it will be found that the particles of sand will fall away, and the form it is squeezed into will not be maintained owing to non-cohesion. The same will occur with burnt moulding sands, *i.e.*, sand that has had the clay matter burnt out by use. A handful of a suitable moulding sand containing about the same amount of water as the seashore sand, and squeezed in the same manner, will maintain its form and coherence until broken by pressure. A handful of newly-fallen snow, squeezed the same as the sand, will be found for the moment to maintain its exact form, even to a feather edge, and having the appearance of possessing bond and cohesiveness. A good moulding sand should exhibit similar appearance.

Water.

The third constituent required in a moulding sand is water. The plastic property of clay is attributed to chemically combined water and the fineness of the particles. But apart from combined water, water must be added mechanically to make the sand workable from the moulder's standpoint. The sand should be neither too wet nor too dry; if

it does not contain sufficient moisture, irrespective of the amount of clay matter, it will not cohere. On the other hand, if it contain too much water the molten metal will blow from it, in green-sand moulds, owing to the generation of steam and hydrogen gas. This may be a rather vague way of dealing with this matter, but the proper amount of moisture in the sand is determined by experience, and works out at 5 to 7 per cent. of uncombined water.

Preparation of Facing Sands.

Facing sands are prepared for moulds according to the thickness of the casting to be made. Thus we use for thin castings a facing sand much weaker than for thick castings. Perhaps it would be as well for clearness to be more definite upon the matter of facing sands, which differ widely in composition and treatment.

In the first place, raw moulding sands as they are quarried and delivered to our foundries differ in the proportions of their constituents, as the following analysis will show. The first three are yellow sands, the second red sands, and for convenience they are classed as strong, medium, and weak sands respectively :—

Analyses of yellow moulding sand.

	Strong Per cent	Medium. Per cent.	Weak Per cent
Silica	80.50	83.10	88 30
Alumina	11.00	9.80	7 69
Ferric oxide	3.20	2.70	2 54
Lime	1.20	1.04	0 72
Magnesia	1.08	0.71	0.58
Loss on ignition	2.38	2.03	0.92

Analyses of red moulding sands.

	Strong. Per cent	Medium. Per cent.	Weak Per cent.
Silica	78.70	81.90	85.30
Alumina	7.57	6.03	5.56
Ferric oxide	2.23	2.34	2 57
Lime	2.70	0.40	0.80
Magnesia	1.73	1.24	0.46
Loss in calcination ..	5.05	1.84	1.62

Both of the above were analysed for the writer from samples chosen and sent by him. It will be seen that the chief differences between the weak and the strong, apart from ferric-oxide, lime, and magnesia, are in the silica, which is heat-resisting or refractory, and alumina, which is also very refractory, and probably, but not necessarily, has a large percentage of clay matter.

Now, it will be seen that if the sub-divisions or classifications of strong, medium, and weak are correct, it is important that sands be obtained as near as possible to suit the nature of the work, *i.e.*, sands which need the minimum amount of mechanical treatment.

A weak sand should contain the least amount of clay matter, and the strong sand the largest amount of clay matter, and the medium comes in between. There is one point about which no doubt exists, viz., that, providing no artificial binder has been added, the strong sand must be used for thick castings, especially where there is great depth, where weak sand would be useless. Also, weak sand should be used for light, thin castings. Then there is the medium sand for the medium-thickness castings.

Green and Dry-Sand Facings.

Facing sand for very light castings, say, about ¼-in. thick, need only be very weak. Ordinary black foundry floor sand with a little coal dust, and a sprinkling of new sand added and mixed occasionally is quite suitable for castings of that thickness. As the castings become thicker so must the sand be mixed stronger, i.e., the proportion of new sand and coal dust must be increased.

When the limit is reached at which it becomes impracticable to make clean castings of great thickness in green sand, then we make the moulds with a facing sand suitable for drying (dry sand). Such a sand requires a certain amount of grinding in a roller mill with rather more water than that added to green-sand facings, say, 6 to 8 per cent. The extent of the milling and the strength of the sand depends, of course, upon the thickness of the castings. Such work as anvil and hammer blocks, and castings of similar kind, requires the strongest and toughest sand.

Amount of Facing Sand Used.

It must be clearly understood that the function of a facing sand is to give the casting a clean skin, i.e.; the sand should strip easily from the casting. It will be obvious that facing sand should not be used in a wasteful manner; it is not necessary to ram the whole of the mould with facing sand.

Facing sand requires preparation, coal dust, opening material, etc., which represents so much money expended, and therefore it should be used sparingly and economically.

The amount of sand to form the face part of a mould in light castings never need be more than a quarter of an inch in thickness. As the castings become heavier, and, of course, stronger, the thickness may be increased to half an inch, and in the thickest castings, which may be three or four feet thick, an inch of facing sand is quite as good as twelve inches. Moulders do not always remember, or, perhaps, they will not remember this; consequently with young and inexperienced men, there is often much facing sand unnecessarily used and wasted. This complaint may to some seem a small matter, but the extra cost of wasted sand during a year becomes a very serious matter for employers.

Different Grades of Facing and Core Sands.

Sand for light, thin castings has already been referred to, and it will be noticed that opening material such as manure has not been mentioned, simply because it is not required in a sand for light work. The sand as mixed is sufficiently porous to allow the air and gases to pass off when such castings are poured. But for thick and very thick castings, when the facing sand is required much stronger and tougher, opening material, chiefly in the form of horse manure, is necessary to give the required porosity. Milled sand becomes tough and dense; we cannot get toughness without density. In the absence of opening material in such a sand the air and expanded gases could not pass off or penetrate through the sand. The consequence would be that the molten iron when poured into the mould would not rest on, or lie quietly against its walls, and as a result a scab or buckle would show itself in the casting.

Coal Dust.

There seems to exist in the minds of some foundrymen a good deal of misconception regarding the function of coal dust. It is not added to the sand to give porosity. It is mixed with the facing sand, so that when the molten iron comes into contact with the coal dust mixed in the sand it generates a gas which deposits a protecting film or

thin covering on the surface of the mould, and prevents the iron fusing the oxides and fusible silicates of the sand. This thin covering or film will resist a higher temperature than that of the molten iron; that is to say, the temperature of the molten iron will not decompose or dissolve this covering the coal dust has formed, assuming the right quantity of coal dust has been mixed with the facing sand, which, as pointed out, must be according to the thickness of the casting. The addition of dry blacking to the facing sand will answer the same purpose, but not in the same manner; the blacking being refractory will give a clean skin to the casting if sufficient is added; but the proportion of blacking required to do this is much larger than that of coal dust; also blacking is very much more expensive than coal dust.

If any reader doubts the function of coal dust, as explained, he may be convinced by making a fairly thick casting in green sand without it. In the absence of coal dust the casting will appear with a dirty white, or grey colour, and a skin of partly-fused weak silicates or oxides of the sand. Such skins are often only with great difficulty removed from the castings. The skin of the iron, of course, is underneath, but its appearance is unsightly.

The Cause and Definition of Scabbing and Buckling.

Seeing that scab and buckle have been mentioned, it may be convenient just now to offer some explanation regarding such occurrences. There are several conditions which contribute to causing a mould to scab, but as this matter will be again alluded to under the title of venting, we will for the present only deal with one of the causes.

If the facing sand or the ordinary ramming floor sand of a mould is too wet, when the molten iron comes into contact with it, scabs occur by reason of excessive moisture generating hydrogen gas or steam which cannot escape sufficiently rapidly through the walls of the mould, but by endeavouring to do so just penetrate a little and push out a portion of the sand which has become dry into the mould space through the molten iron. This penetration is rapidly repeated so long as the metal remains in a liquid state, or the gas is still generating and cannot escape any other way, and quite rough lumps are left on the casting. During the time the scabbing is taking place the gases are following the line of least resistance by passing through the molten iron into the runner gates and risers with a series of puffs and blows, which are actually little explosions from expansions.

Core Sand.

Sand for green-sand cores should be graded in the same manner as facing sand. Cores for small thin castings should be made of weak sands, and as the castings become thicker and heavier so should the sand become stronger.

Dry-sand cores to some extent should be made on the same lines, but, as a rule, a better and firmer core, whether large or small, is made when the sand has been milled with an abundance of opening material, such as manure, fine saw-dust, etc., ground in and well mixed together, which will make the sand quite open and porous, and more easily cleaned from the castings when being dressed.

Loam.

Loam is made of milled moulding sand, ground with water to give plasticity, manure and other opening material to give porosity, and cow hair for cohesion. These materials are milled to a consistency which may be stiff or sloppy according to the work required. If the loam is required for bricking only, it may be coarse and porous, but if required for finishing, that is the last striking course, then it must be finely ground.

It may be interesting to say before leaving the subject of sand and loam, that a weak or strong sand by being milled in a roller mill will greatly increase in bond, and up to a point the increase in bond will depend upon the length of time the sand remains in the mill. Of course, the sand can be entirely spoilt and made unfit for moulding purposes. The continual grinding can make the sand so close, dense, and clayey that air will not pass through it.

It is obvious that this condition is not brought about by an increase of clay, but by the clayey particles present in the sand being ground closely into each other. Of course, additional water up to a point adds to this state of density and toughness. On the other hand, if the mill is charged with a sharp sand, better known as sea-shore or beach sand, the mill may grind away the whole day long, with or without water, but the sand will acquire neither bond nor plasticity.

Oil-Sand Cores.

The foregoing remarks would not be complete without reference to the use of oil-sand. The most intricate cores, both large and small, are now made from beach or sea sand with an artificial binder in the form of an oil. There are several kinds of oil suitable for this purpose. The proportion of oil varies from half to one pint to one bucketful of sea sand; the only other addition being about 5 per cent. of water.

The advantages of oil-sand cores are that the mixture of sand is cheap and the cores when properly made and dried are hard, will maintain their proper form and firmness with a minimum of support from core rods and irons, and also have maximum porosity, thus allowing the gases to escape freely. The drying of these cores needs care, as they crumble away when handled if they get too much fire; and if not sufficiently dried, a large amount of gas is created when the mould is being poured. When properly dried, water should be absent and just sufficient oil left in the sand to keep the core firm and hard, so that it can be handled and stand the pressure of the molten iron. Proper drying is only achieved by experience.

Blackings.

The blackings used include charcoal, plumbago and blacklead. Each of these is generally prepared as a compound, but they are all carbon in a more or less pure state. The first, as its name implies, is made from wood which has first all the volatile matter burnt out of it, and is then ground into powder. It is a light carbon blacking chiefly used for mixing with other blackings, sometimes with sand and often for covering molten iron in the large ladle to keep the surface from crusting or solidifying.

Plumbago blacking is a mineral carbon, and is obtained in large quantities from India and Russia.

It will without any addition make an excellent and suitable blacking for moulds either light or heavy, and is useful for mixing with other blackings of less density and purity. Blacklead, as I have called it, is also a mineral carbon of a graphite nature. It possesses a shining metallic lustre. It is too heavy and rich in itself to be used alone for a blackwash, and is added in small quantities to other inferior blackings to give some body to them. It is often used in the dry state for dusting moulds to give the castings a bright, shining, clean appearance.

Clay Wash.

For black-washing moulds all blacking must be mixed with claywash, which is common clay mixed with water. This claywash is mixed thick or thin, or, as we term it in the foundry, strong and weak; for light work thin claywash, for heavy work thick claywash. As this is mixed in an iron tank or "bosh" it is not easy to put into words the percentage or proportion of clay and water; the usual rule-of-thumb method is adopted by judging its suitability in the handful.

If the blacking were mixed with water only, the blackwashed surface of the mould when dried would not sufficiently resist the fluid iron during pouring; the surface of the blacking would lack hardness, so much so that it could be rubbed off the mould quite easily by rubbing the hand over it, and it would be liable to erosion by the passage of the fluid iron. The claywash acts as a binder to the blacking, and both the carbon blacking and the clay in the wash being of a very refractory nature it resists the high temperature of the iron in regard to fusibility of the mould and leaves a clean bluish skin on the casting.

Blackwash, of course, is only used for dry-sand work and loam work, both moulds and cores. If the blackwash on either moulds or cores shows signs of peeling when dried, this indicates that the claywash is too strong; on the other hand, if the casting shows excessive erosion and does not give a clean skin it indicates that the claywash, or the blacking, has been too weak.

It is the custom with some moulders after blacking a mould to wash it over afterwards with water to give it smoothness, and some carry this on to such an extent that they wash practically all the blacking off again. This is obviously wrong, for the casting when turned out appears just the same as a green-sand casting would if no coal dust were put in the facing sand, with a dirty grey-white skin of partly-fused sand instead of a clean blue skin of iron.

Summary.

The chief points to be remembered are:—

Facing sand is to give a clean skin to the casting. It should be put against the pattern only, and not be used for ramming the whole of the mould.

If dry blacking be dusted on green-sand moulds it should be sleeked in, not blown off again with the bellows.

The thinnest green-sand castings require in the facing sand the least amount of coal dust, and weakest sand. The opposite is required in the thickest green-sand castings.

When wet blacking is used on dry sand or loam moulds and cores it should not be washed off again with water.

If sufficient blacklead be rubbed or sleeked on a green-sand mould coal dust may almost be absent in the sand.

A few Mixtures of Facing Sands used ina General Foundry.

No. 1.—*For very light green-sand machine-made castings.*—Two barrows of fine new sand; four barrows of good floor sand; three buckets of coal dust; the whole mixed and passed through a rotary mixer.

No. 2.—*For light green-sand work.*—Two barrows of new sand; 3 barrows of old sand; 3 buckets of coal dust; 1 bucket of dried manure (not milled).

No. 3.—*For medium green, or skin-dried work.*—Sixteen shovels of new sand; 4 shovels of old sand; 1 bucket of coal dust; 2 shovels of dried manure; milled for five minutes.

No. 4.—*For dry-sand heavy work.*—Half new sand; half old sand; 4 shovels of manure; milled for ten minutes.

Core sand for heavy work.—All new sand, with three shovels of manure; milled fifteen minutes.

Core sand for light and medium work.—Half new sand; half old sand; 3 shovels of manure; milled for 15 minutes.

Blast-Furnace Dust.

The Minister of Munitions has issued an order providing that no person shall buy, sell, deal in or dispose of any blast-furnace dust, except under, and in accordance with the terms of a licence issued on behalf of the Minister of Munitions by the Controller of Potash Production, and that no person shall treat any such dust so as to extract any component part thereof, except in accordance with the terms of the licence. Other regulations are given below:—

All persons producing, or in possession of, blast-furnace dust, shall make returns in regard to rate of production, stocks, purchases, sales, dealings or other matters relating to blast-furnace dust in such form and at such times as may be required by the Controller.

Samples of any blast-furnace dust produced by or in the possession of any person shall be furnished to the Controller by such person in such form and quantity, and at such times as the Controller may prescribe. Such samples shall be taken in such manner as the Controller or his authorised representative may prescribe.

For the purpose of this Order blast-furnace dust shall mean dust deposited or otherwise derived from the gases of any furnace used for treating ores for the production of iron or any of its alloys.

All applications in reference to the Order should be made to the Controller of Potash Production, Ministry of Munitions, 117, Piccadilly, W.1.

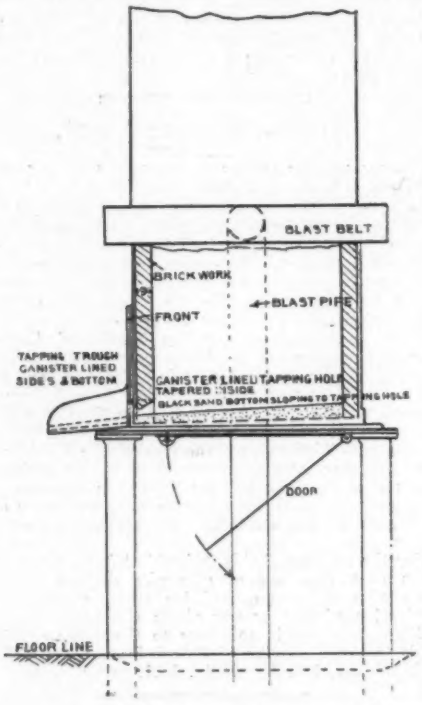
EXPLOSIONS IN SMALL CONVERTER PRACTICE. — A writer in a recent issue of "Stahl und Eisen" calls attention to the numerous cases of small explosions reported lately as having occurred in small converter practice in steel foundries. According to him these explosions generally occur with over-blown charges. He mentions a recent case within his own experience. A charge was finished in about eight minutes, but as the metal was too sluggish for teeming, the shop manager decided to continue the blowing. The after-blow having lasted four minutes, the characteristically green flame, with small illuminating power, made its appearance, and small pellets of slag began to spatter out. The converter was then turned down, and the finishing iron added, when in about 15 seconds the charge began to burst into flames, at first slowly, then more rapidly, and a series of small explosions took place, which scattered lumps of slag to a distance of over 30 yards. The explosions, according to the writer, are the more violent, the more the charge has been over-blown, and he thinks the behaviour of the metal is due to the well-known reaction of the ferrosoferric oxide in the slag upon the carbon in the finishing iron.

Preparing a Cupola.

By A. R. B.

The following notes relate particularly to the making up of the bottom of a cupola and the material to be used therefor.

We have four cupolas installed, and from two of them it is common practice to get 120 tons of metal per day if necessary. The average from one cupola for the year is about 50 tons per working day. The cupolas range in size from 2 ft. 6 in. to 5 ft. inside the brick lining. All have hinged bottoms for dropping, the smallest one being hung on the one side, as shown in the accompanying



Method of Lining a Cupola.

sketch, and the others having the bottoms made in two, so that the bottom when dropped opens in the middle, being hung on hinges from both sides instead of on one side only as in the small one.

The pressure of blast used is about 12 to 14 ozs., and the wind enters the furnaces from the wind belt by four tuyeres in the case of the small furnace, increasing in size and number with each size furnace, the second size having six tuyeres and the two largest having ten tuyeres each. The cupolas mentioned have only one main blast pipe, admitting air to the wind belt in one place only. I mention this as many cupolas have air admitted to the wind belt on two opposite sides; but, to my mind, it makes no difference how the air is admitted, if the desired volume gets into the cupola. The wind is prevented from going into the cupolas not in use by means of a valve attached to the branch pipe, which leads from the main wind pipe to the wind belt. All the tuyeres are round at the hole admitting the air to the cupola, and as regards position in the wind belt they are staggered.

The lowest tuyeres in the small cupola are 10 ins. from the highest part of the bottom when made up, and in the case of the largest cupola they are 14 ins. from the bottom when made up. All the cupolas are bricked lined up to 9 ins. thick, the bricks being made to suit each size of cupola. The lining is, of course, left out where the tuyeres are, and where the tapping hole is to be made. Our practice is to have a hole about 6 ins. square for this purpose, in which after every blow a new tapping hole is made. The method is as shown in the accompanying sketch, viz., to make a tapered hole from the front of the cupola to about the centre of the 9-in. wall, where the hole is then enlarged again, making a tapered hole again with the largest side in the inside of the cupola. (See sketch.) The size of the hole is governed by the amount of molten metal the cupola is capable of delivering, so that the charging of the cupola, the melting and the flow of the metal into the ladles, are not out of balance. This can only be determined by the men who have to work the cupola, and who have arrived at what its capabilities are, and who know the little ways of the cupola, for each one of them has a way of its own which eliminates the possibility of any hard and fast rule. Speaking generally, the tapping holes that suit our cupolas are $\frac{3}{4}$ in. in the smallest part of the tapping tunnel, tapering up to 3 ins., both on the inside and the outside of the cupola. This applies to the two smaller cupolas; the one running 5 tons per hour, the other 8 tons per hour. The smallest part of the tapping tunnel on the two largest cupolas ranges from $\frac{3}{4}$ in. to $\frac{7}{8}$ in., according to whether we are running on a long tap or not. If running for a casting of, say, 30 or 40 tons we make the hole slightly larger, right up to the capacity of its melting powers, so that it delivers the metal as fast as it can be charged. The whole of the tapping tunnel, the hole and the tapping trough are lined and made up with fresh gannister after every blow on the larger cupolas, and the hole and tunnel on the smaller ones, the trough on the smaller ones lasting some considerable time with slight patching.

The cupola bottom in every instance, no matter whether on the small or the large cupola, is made up with the ordinary black floor sand. The mode of procedure is to patch the sides of the cupola, where burnt away in the melting zone, with gannister; then close the bottom and make secure in position. The black sand is then thrown in through the back door of the cupola by one man, while one inside treads it solid, the ramming round the side close to the brick lining with a pin rammer to make sure of it being tight and secure. The sand is then shaped to form a graduated slope from all points towards the bottom of the tapered tapping tunnel, and then flat-rammed quite solid. By this method, it will be seen, the bottom bed is made hard close to the wall of the cupola and on the top surface of the bed; the lower part of the bed being

only trodden with the man's feet, is rendered slightly porous, so that the gases generated, as in a mould, get out through the cracks and joints of the drop bottom. I might here mention that the sand bottom gets very open with constant use, for it is used over and over again, and gets a large amount of small coke and slag mixed with it. The reason for this is that after the bottom is dropped at the finish of the blow, the heap of sand, coke and slag, with possible small pieces of metal, is raked and spread out, while a man plays water on it with the hose-pipe. When there is no risk of it burning, it is then left till the morning, when it is picked over and sifted. The sand thus gets a very large proportion of fine coke and slag mixed with it. The sieve used is one with ¼-in. mesh. The heap of rough and open sand thus obtained is always what the bottom is made up with. The only replenishing it gets is from the fresh black floor sand that is used when making up the back door after the fire is well alight. This, of course, is done every time the cupola is used, and thus keeps the bottom sand always of about the same consistency.

The depth of sand forming the bottoms is 6 ins. in the front near the tapping hole to 8 ins. at the back nearest the door, thus giving it a slope of 2 ins. This applies to the smallest cupola. The largest has a depth of sand, nearest the tapping hole, of 8 ins., tapering from a depth of 10 ins. at the back door. The cupolas in between have beds proportionately arranged on the same basis. It is advisable to light the fire as early as possible to ensure that the bottom gets well dried, also the tapping hole. The hole is usually dried with a hot bar and must always be thoroughly dried, otherwise the risk of a set tap hole is very great, and every foundryman knows what a great nuisance this is, entailing a lot of hard work and a spoilt tap hole driving a bar into the set metal and making a new hole, which is never satisfactory, even if one is fortunate enough to get through.

Substitutes for Ferro-Manganese.

In a letter to "The Iron Age," Mr. W. A. Janssen, of the Bettendorf Company, Iowa, observes that with the shortage of supply of the 80 per cent. ferro-manganese and its excessive cost, due to the cessation of exports from Europe, the American steel-makers became somewhat pessimistic and fearful for the source of supply of this all-important constituent, and many of them resorted to the use of spiegeleisen. On account of the low manganese content and the proportionately larger amounts necessary to be used, they were forced to the additional cost and inconvenience of preheating this material. Some others reduced the percentage of 80 per cent. ferro-manganese and in addition used an equivalent amount of specular irons of lower percentages in order to offset the initial preheating. "With the embargo which has been placed on Caucasus ores by the Allies," proceeds the writer, "Germany has been able to meet the shortage of ferro-manganese by the use of calcium-silicide. American steel manufacturers have tried as a substitute a by-product of the abrasive industries, known as silicon-aluminium-titanium, with indifferent and variable success. Realising that the function of manganese in the final product contributes to the ultimate strength of steel only indirectly, in that the usual percentage of approximately 75 points of manganese assures complete de-oxidation and a resulting homogeneity, some tests were instituted wherein the final manganese content was reduced about 35 per cent. further. In the preliminary experiments the original ferro-manganese addition was reduced about 35 per cent. and the de-oxidation was further augmented by the use of ferro-carbon-titanium. Although ferro-carbon-titanium normally sells at a considerably higher price than ferro-manganese, its substitution was economically possible at the current price of 80 per cent. ferro-manganese, permitting the conservation of the present supply of the latter. Physical tests indicated that the elastic limit, ultimate strength, elongation and contraction were the same as in previous practice when 80 per cent. ferro-manganese was in abundance. Further economies were found from experiments which led to the use of 30 per cent. of the original 80 per cent. ferro-manganese addition, augmented by twice the amount of 40 per cent. spiegel and the addition of 3 lbs. of ferro-carbon-titanium alloy per net ton of metal charged."

PROPOSED LARGE METALLURGICAL WORKS FOR SPAIN.—At the general meeting of the Sociedad Española de Construcción Naval, recently held at Madrid, the directors proposed and were empowered to proceed with the preliminaries of a scheme for large works to supply the necessary material required by the national arsenals and the shipbuilding industry, such as forgings, castings, shapes, and special steels of every kind and copper, brass, and special bronze articles for which Spain has, until now, been dependent on foreign countries, and in the procuring of which the difficulties are increasing day by day. The aim henceforth will be that ships and war material must be built in Spain entirely of materials produced in the country.

USE OF NITRE CAKE IN THE PICKLING OF ANNEALED BRASS.—In a Paper before the Birmingham Section of the Society of Chemical Industry, Mr. H. W. Brownsdon pointed out that under present conditions the quantity of sulphuric acid used for pickling annealed brass must run into several hundred tons per week. Difficulty in obtaining raw material, coupled with the increased demand for sulphuric acid for other purposes, has resulted in an extended application of nitre cake solutions in place of dilute sulphuric acid for pickling annealed brass. Nitre cake is essentially crude acid sodium sulphate, and whilst the latter in the pure anhydrous state contains theoretically 40.3 per cent. of sulphuric acid, the free acid found in nitre cake may vary from 5 to 30 per cent. For pickling, the nitre cake solution should show 3 to 5 per cent. of sulphuric acid on titration; there is no advantage to be gained in using solutions of higher acid concentration. Whilst nitre cake is a variable product, annealed brass from a pickling point of view may be even more so. Given clean work, nitre cake solutions replace dilute sulphuric acid quite efficiently, but with dirty work the difference is much more marked, and nitre cake solutions, even under the most favourable conditions, may fail to pickle the work satisfactorily. It is little consolation for the manufacturer to know that his troubles lie in his annealing furnaces. Much may be done on the following lines in this direction. (a) The nitre cake solution should be as hot as possible; (b) its acid content should be tested frequently and maintained at 3 to 5 per cent. by the addition of nitre cake; (c) the hot annealed products may be quenched in water, whereby much scale is mechanically loosened prior to pickling; (d) the hot annealed work may be placed direct into the nitre cake solution, and the pickle can thus be maintained at a high temperature without auxiliary steam heating; (e) oxidising agents such as ferric salts, bichromates, or persulphates may be added to the pickle, but in many cases the price is prohibitive; (f) electrochemical aid might be sought by using a low voltage current, making the lead lining of the vat the cathode and the work to be pickled the anode; (g) the movement of the work in the pickle, or the agitation of the pickle during pickling, or both. The difficulties met with in the successful use of nitre cake solution can only be overcome in a satisfactory manner (1) by paying close attention to the conditions governing the annealing, so as to obtain the annealed brass as clean as possible, and (2) by using the nitre cake solution under conditions which will most strongly stimulate its pickling activity.

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Industrial Co-Operative Research.

Before the Society of Chemical Industry recently, Mr. H. W. Rowell, of Rochdale, supported the proposal that industrial research should be State-aided and systematically encouraged by manufacturers. He pointed out that at many works the chemists and engineers were considered, not as the most fitted people to originate new ideas, but rather as skilled workers to carry out improvements suggested by the works managers. The chemist had failed in part to appreciate the multitude of difficulties encountered in carrying out a process in the works, and had thus unwittingly brought upon himself the contempt of the practical man, whose careful observation of physical phenomena often kept a works in operation. A give-and-take policy between these two extremes and a broad-minded leader of an industrial research organisation were essential. The only fit person to undertake the control of research and the development of industrial technique was the scientifically-trained chemist, engineer or physicist. All matters of research and experiment in an industrial organisation should be centralised in a central laboratory under the control of one person. Routine control testing should be done in separate works laboratories under the general direction of the research department. The laboratory in large organisations should include an experimental factory, and in small ones the experimental floor could be profitably used for manufacturing small lines as raw material for works operations or, in some cases, for direct sale. The special function of a research laboratory being to exploit new principles, it should not be tied to the history of the works and its natural bias to patch on to existing methods. In large organisations the research staff should be divided into departments dealing with separate types of chemical and physical work, each under a qualified superintendent, with arrangements to secure combined action where necessary. Whilst the initiation of research should be principally with the head of the research department, credit should be secured for ideas and improvements by those who originated them. This could be done by suggestion bureaux, and, in the case of the management staff, by direct report to the executive. Wherever possible, the results of research should be covered by patent rights, but where it could be done without damage to commercial interests results should be contributed to the common stock of scientific knowledge. The cost of the research should be estimated, where possible, or a definite sum should be allotted by the executive for experimental plant and laboratory expenses. Comprehensive and detailed records should be prepared and indexed, and kept together with typical and standard specimens.

Dealing with schemes for co-operative industrial research, Mr. Rowell said that the essential points were:—

(1) That a properly equipped laboratory and experimental station should be established on such a scale that it could afford to employ experienced industrial research men of high grade to organise and supervise the research and experiments.

(2) That the manufacturer might safely entrust all the details of his processes to the organisation without risk to business interests.

(3) That discoveries made should be the property of the manufacturers initiating and bearing the cost of the experiments.

(4) That the cost of experiments should be decidedly less than if the manufacturer had employed his own staff and laboratory, and that the probability of success should be greater.

The idea had been seriously suggested that the Government should unite with the learned Societies and the Universities in the provision of research facilities for smaller works, but the manufacturer saw that red tape, delay, high cost, and commercial inefficiency would make such a combination entirely useless. Individual firms in many industries would have to formulate working agreements of various kinds if they were to meet successfully world competition. A scheme of co-operative research for a whole trade, such as those which existed in some trades in America, was the most profitable to all concerned, but the value of such a scheme to small works was doubtful, and there seemed to be no probability of British manufacturers combining in this wholesale way for many years to come. Something less ambitious, organised in such a way that it could be developed into the full scheme as progress was demonstrated, seemed to meet our present state. If it were made into a limited company, with a scale of payments to it for the use of the ideas evolved, the commercial aspect of the laboratory could be easily solved. The cost of such a scheme would be small, and the results of distinct value.

In the iron and steel trade, he said, if such an organisation could make blast-furnace slag worth a shilling a ton or reduce production costs by a shilling per ton of pig, its existence would be amply justified. The trade was faced with big rises in prices of ore, fuel and labour after the war, and when the demand for munitions ceased the only way to meet foreign competition at home and abroad was by making the fullest use of expert advice. Taking the large number of works engaged in the non-ferrous metal trades of Birmingham district — mostly small concerns — the author said that practically none of them employed a chemist or metallurgist, because of the comparative cost, yet they all felt the need of expert advice. Except for certain mysterious "dopes" which were added to meltings—often without practical effect—some foundry methods and a very few special alloys, which could easily be analysed, there were no secrets in the trade, and business interests would not be adversely affected by the institution of a co-operative laboratory. Quite a modest affair could be started for analytical work and general advice on technical problems, but this should be designed to expand into a full research department and experimental works where problems of fuel consumption and furnace design, crucibles, heat-treatment of castings, casting methods, micro-structure, rolling and stamping and finishing, could be solved to meet the severe competition of scientific methods employed in Germany and America.

DRINKING WATER IN WORKS AND FACTORIES.—The Home Secretary gives notice that he proposes to make an Order in regard to the supply of drinking water—to take effect from October 1, and to apply to all factories and workshops in which 25 or more persons are employed. The Order will require the provision (*a*) of an adequate supply of wholesome drinking water from a public main or from some other approved source of supply, which shall be either laid on or contained in a suitable vessel; and (*b*) (except where the water is delivered in an upward jet from which the workers can conveniently drink) of sufficient cups or other suitable drinking vessels.

Electric Furnaces in United States Steel Foundries.

In continuation of our survey of recent electric steel developments in the United States, we append further abstracts of Papers read before the recent annual general meeting of the American Electro-Chemical Society at Detroit, Michigan.

ELECTRIC STEEL MELTING.

A Paper entitled "Notes on Electric Steel Melting," by MR. J. L. DIXON, of the John A. Crowley Company (owners of the American patent rights of the Gronwall furnace), first dealt with mechanical and electrical considerations of furnace design. The author said that, mechanically, great strength was required. The design and location of the gears must be such that they are fully protected from any accidental break-out or overflow of liquid metal. With all possible precautions, break-outs or overflows will occur, and it takes only a few pounds of liquid steel to put a lifting screw or a worm gear out of business. The protection of the electrode-raising gears is generally quite a simple matter, but not so with the tilting gear. In the Gronwall-Dixon furnace a tilting gear giving excellent results mechanically has been abandoned owing to the danger of the gear being damaged by liquid metal. Another essential, perhaps the most important, is to avoid too great intricacy. Whatever the cause of the breakdown it is certainly unpleasant to have to stand on the roof of a hot furnace and endeavour to remove the broken-down part, either by unbolting or by cutting it away with a hacksaw. In designing a very large electric furnace, requiring a large number of electrodes, the difficulties may be overcome by suspending the electrodes from an overhead device quite independent of the shell of the furnace. This will certainly be the most convenient arrangement if the furnace is not tilting but is of the stationary type, as is quite probable with the very large furnaces that will come in the future.

Electrically the power factor is important, and in a well-designed furnace the power factor should be 90 per cent. or more. The power factor is improved by (1) an increased number of electrodes, more especially if they are all of different polarities; (2) by a higher voltage on the electrodes.

With respect to current fluctuations or overloads, again an increased number of electrodes is beneficial, owing to the spreading and averaging effect. A higher voltage on the electrodes tends to increase the fluctuations, but this may be largely overcome by reactance without seriously lowering the power factor. This question of current fluctuations and disturbances is often a very serious one, more especially with furnaces connected to small power stations, and some radically new design in automatic controlling apparatus is necessary. The various kinds of apparatus in present use are of excellent workmanship, but in principle they do not go sufficiently to the roots of the trouble.

Take for instance, the case of a three-phase furnace with three upper electrodes. When there is an overload on one of the electrodes either one or both of the remaining electrodes are also overloaded, even though at that moment they are correctly located relative to the bath of metal. But the fact that they are correctly located is not observed by the automatic controlling apparatus which, acting under the impulse of the increased current, raises these electrodes, so that when the offending electrode is brought to its correct position the unoffending electrodes are carrying currents that are too small. In this way a more or less continuous "hunting" is set up, and partly on account of this the automatic controlling apparatus has to be "damped," which lessens its sensitiveness and ability to deal quickly with any real trouble that may occur.

The author expressed the opinion that furnaces with a bottom electrode are more easily controlled than those without, because any fluctuation of current in one of the upper electrodes is partly taken care of by the bottom connection instead of being absorbed entirely by its remaining upper electrodes. In this way the "hunting" due to what may be called false regulation is to a large extent avoided.

The author then took up thermal considerations and advocated the highest possible voltage for melting down the charge. Obviously the higher the voltage the smaller might be the electrodes and the higher would be the power factor. With furnaces of ten hours' capacity and upward, a voltage higher than usual had been found to be absolutely essential, but even in smaller furnaces there were advantages in this respect not directly attributable to the smaller resistance or induction losses. During the refining period it was essential that the voltage be lowered, so that the arc became practically buried in the slag. This was especially essential if a white deoxidised slag was obtained, as such a slag was a good heat insulator and reflector, and the heat of the long arc would be reflected on to the walls and roof of the furnace.

The author went on to say that a lower electrode has a distinct value from a thermal point of view. On occasions when he had operated a furnace without a lower electrode, he had experienced greater difficulty in maintaining the furnace bottom in good shape, and, more especially in making high-chrome steels, had experienced difficulty in dissolving the alloy additions. For the furnace bottom he had always obtained good results from either magnesite or dolomite tamped in with tar.

As regards the walls and roofs, continued the author, everyone operating electric furnaces is aware that these receive their greatest punishment at the end of a heat. This no doubt is largely due to the reflecting power of the white slag. In addition to this, however, the writer is inclined to believe that there is some chemical influence very active at that time. As is well known, silica bricks absorb mechanically-occluded iron oxide (Fe_2O_3); at the end of the heat when the atmosphere of the furnace is strongly reducing the Fe_2O_3 is reduced to FeO, which at once fluxes with the silica.

Finally discussing chemical considerations, the author said that the acknowledged advantages of a white slag are sometimes attributed to the strongly reducing effects of calcium carbide. He is inclined to disagree in this, and to attribute the

good results not to the presence of calcium carbide but to the absence of reducible oxides, the presence of the carbide being merely a symptom that the deoxidation is approaching completion. It is obvious that, as a result of chemical equilibrium, if there is no oxide in the slag there can be very little in the metal.

The author was unaware that the mechanism of the reactions by which sulphur is eliminated had ever been described. He believed the reactions to be somewhat as follows:—

$$(a) \qquad \frac{\text{FeS in slag}}{\text{FeS in metal}} = \text{constant}$$

Disregarding the presence of manganese, the only way in which the amount of sulphur (FeS) in the metal might be adjusted was by some alteration of the proportion of FeS in the slag. An increase or decrease of any other sulphide in the slag would have no direct effect on the amount of sulphur in the metal. This was because any other sulphide, in this case CaS, was insoluble in the metal. In the slag itself the following equilibrium was established:—

$$(b) \qquad CaO + FeS \rightleftarrows CaS + FeO$$

This might be written as follows:—

$$\frac{CaO \times FeS}{CaS \times FeO} = \text{constant}$$

From this it followed that any decrease in the FeO in the slag would cause a decrease in the FeS, until, when the slag was free from FeO, all the sulphur existed as CaS. Referring to equation (*a*) it followed that when there was no FeS in the slag there was no sulphur in the metal. Probably the slag might consist of CaS entirely without affecting the steel in any way.

Something might be said as to the effect of magnesia in the slag. MgO in the slag was generally recognised to be very undesirable. At the best the MgO diluted the slag and also robbed it of fluidity, so that for a given degree of fluidity an increase in the proportion of MgO meant a much greater decrease in the proportion of the active constituent, CaO. In addition to this, however, it would appear that MgO was actively harmful, and the author believed that under the electric arc it acted as an oxidiser.

Several years ago, when burning in a magnesite bottom by lowering the electrodes on to a shallow bed of coke, it was found that whenever the arc came near to the magnesite bottom deep channels were cut in the bottom. It was apparent that the following reaction was going on between the coke and the magnesite:—

$$MgO + C = CO + Mg$$

Directly the vapours of CO + Mg got away into the cooler parts of the furnace, the reaction was reversed, and there was deposited on the walls of the furnace a powder consisting of finely powdered MgO and soot.

Possibly some reaction similar to this goes on between the MgO in the slag and the carbon in the steel and the carbon, such as coke, thrown on to slag for deoxidising. Also it is possible that MgO reacts with metallic iron, forming Mg which is lost by volatilisation and later reoxidation, leaving FeO in the slag.

The author said he remembered with painful distinctness several heats in which the carbon could not be moved from about 0.10 per cent. Pig-iron was added with no effect; about a ton of pig being added to a five-ton charge. No scale or ore had been charged, and the disappearance of the carbon could only be explained by some of the above assumptions as to the action of the magnesia in the slag.

These experiences were of several years ago, and by fettling the hearth of the furnace with good dolomite and making the slag from fairly pure lime, the difficulties were soon overcome.

THE BETHLEHEM 10-TON GIROD STEEL FURNACE.

A Paper by Mr. C. A. Buck, of the Bethlehem Steel Company, described the 10-ton Girod furnace now in operation at the Bethlehem Steel Company's plant in South Bethlehem, Pa. This furnace made its first heat May 16, 1916, and had made a fairly consistent run to date. Until September 1 the furnace operated on single turn, but since then had been in continuous operation, except when down for repairs or power. To February 23, 247 heats had been made, and the quality of steel produced had been gradually improved.

The furnace was cylindrical in form, and made of ¾-in. steel plate, approximately 15 ft. in diameter and 5 ft. outside depth, with laminated outside plates, ¾ in. thick. It was equipped with one heavily laden, counterbalanced charging door, sliding in a water-cooled frame. The pouring spout was directly opposite. On the side of the shell heavy copper angles were attached to which were electrically connected laminated copper bars conveying current from the transformers.

The furnace, continued the author, rests on heavy cast-iron rockers running on rollers supported by rocker frames anchored to concrete foundation. The tilting of the furnace is accomplished by means of worm drive, actuated by a 15-h.p. motor. The furnace can be tilted toward the charging side to discharge the slag through a notch in the charging door, or toward the pouring side to pour the molten metal into a 2½-ton ladle located in the pit in front of the furnace. The bottom, 20 in. in thickness, is made of double-burnt dolomite well rammed in with tar. The metal bath is approximately 16 in. thick. Fourteen soft-steel poles approximately 3½ in. in diameter are connected electrically to the bottom of the furnace shell, the lower ends being water-cooled. The roof construction, which is arched, consists of 9-in. silica brick, insulated from the magnesite brick of the hearth walls by means of asbestos plates, with provision for reception of three 17-in. amorphous carbon electrodes. The electrode coolers in the roof are made of copper and are water-cooled. Ample provision has been made for adjustment, so that the electrodes can be adjusted and centred firmly and speedily. Two laminated copper bars carry the current from the transformer to the contact pieces extending from the electrode carrier. The lowest point of an electrode during operation of the furnace is approximately 4 in. above the surface of the metal bath.

The electrodes are raised and lowered by means of a revolving screw spindle centred in the structural column, which is driven by a 5-h.p. motor mounted at the foot of the column, or, if necessary, it can be operated by means of a hand wheel. The total weight of one electrode-carrying column is approximately 2,600 lbs., the weight of an electrode being about 1,000 lbs.

The motors employed for this work are of the reversible interpole type, using direct current at 230 volts, and equipped with automatic speed regulation. The total weight of the furnace is approximately 90 tons, which includes about 35 tons of refractories. About 1,500 k.v.a. of 3-phase alternating current, 25 cycles, 65 to 80 volts, is furnished to the electric furnace, each electrode receiving one phase of a 3-phase current, the conducting hearth of the shell acting as the neutral point. Special care has been taken to prevent the formation of induced currents in the shell and the roof frame, and to prevent sparking from the bus-bars at the lower end of the electrode-carrying column to that column in electrical contact with the shell. The current is conveyed to the furnace from three water-cooled single-phase transformers of 700 k.v.a. each. It is generated by Bethlehem gas engines driving 2,500-kw. generators, producing 3-phase alternating current of 6,600 volts at 25 cycles. One reactance coil of 106 k.v.a. capacity has been provided for the protection of each transformer. A special controller for each electrode is mounted in front of the switchboard, and one controller is provided near the pouring spout for the operation of the tilting motor. Of the 700 k.v.a. leaving the three transformers, about 620 k.v.a. actually reach the electrode holder, the balance being lost in the form of heat through water cooling, etc. The consumption of cooling water at the furnace is about 20 gallons per minute. The yield from cold charge to finished ingots is about 92 per cent.

A thoroughly equipped laboratory erected for the open-hearth department, which is adjacent to the electric furnace department, takes care of the necessary testing of the steel, etc. The electric furnace will become a valuable adjunct to the Bessemer converter and the open-hearth furnaces, as a means of refining their molten product. It is believed that the greatest field for this grade of steel will be in the alloy steel market and for many grades of tool steels. Thus far the following steels have been made—1.5, 2.5, 3.5 per cent. nickel, nickel-chrome with 0.50 chromium, chromium-vanadium, and simple carbon steels ranging from 0.08 to 1.30 per cent. carbon.

The materials used for steel-making are as follows:—Scrap rails, high-phosphorus turnings, billet crop-ends, drop-forge trimmings, etc., which mixture should average 0.040 sulphur.

The operation of the furnace is very similar to that of the basic open-hearth. Following the tapping of a heat, turnings are charged and levelled down. Any necessary repairs along the slag line are made with dolomite. Billets or other heavy scrap are next charged, following by turnings, until the entire 21,000 lbs. charge is in the furnace. Lime is then added, current turned on, and melting is begun. Much of the phosphorus is removed through combustion, carbon is reduced by oxidation, and some of the sulphur is removed. The length of time required for the oxidation is dependent upon the carbon aand phosphorus content of the charge. When it is considered that the oxidation has proceeded far enough, a test-piece about 2.5 in. diam. and 2 in. long is taken, forged under a hammer, quenched in water and bent through 180 deg. When the test bends without breaking through the bend, the oxidising slag is removed by tilting the furnace backward and skimming off slag through the charging door. Slag flows through a shute in the charging floor into a slag car under the floor.

Following removal of the oxidising slag, the recarburiser is added, followed by the deoxidising slag of powdered petroleum coke, silica sand, lime and fluorspar. This slag dissolves ferrous oxide which has formed on the surface of the bath. A reasonable time after the addition of the deoxidising slag a test is taken for the laboratory for carbon determination. Varying amounts of ferro-silicon, ferro-manganese, etc., are added to bring the slag to the point where it becomes white, and quickly disintegrates into a fine white powder. These alloys act very energetically on the oxide in the bath, forming a very fluid slag, which easily rises to the surface. During this period, when the slag is completely deoxidised and is very basic, the desulphurisation, which was incomplete during the first stage of the operation, proceeds further, and is rapidly completed at the time of tapping.

The average analysis of the preliminary tests taken after the charge is melted and before removal of oxidising slag is as follows:—C. 0.07 per cent.; Mn. 0.11 per cent.; P. 0.008 per cent.; S. 0.036 per cent.; Si. 0.022 per cent. The analysis of oxidising slag from heat Y-1,219, a high-carbon simple steel heat, and of the finishing slag at time of tapping showed:—

	Oxidising slag. Per cent.	Finishing slag. Per cent.
SiO_2	8.89	6.49
FeO...	36.82	1.26
MnO	4.71	0.16
CaO...	35.26	69.83
MgO	9.25	2.61
P_2O_5	0.705	0.092
S	0.19	0.34

This heat finished with phosphorus 0.010 and sulphur 0.016. Several heats have been made since this one analysing below 0.010 P. and 0.015 S. All these heats are entirely satisfactory from a metallurgical standpoint. The ingots rolled well, and in many cases it was not necessary to chip a single billet.

Nearly all the heats thus far have been cast in 19 × 19 in. × 6,000-lb. or 21 × 27 in. × 12,000-lb. ingots, and the practice on the 35-in. bloomer mill on the various grades has been from 75 to 82 per cent.

ELECTRIC ANNEALING FURNACE.—An electric annealing furnace 193 ft. long is now being built by the Electric Furnace Company, of Alliance, Ohio, for use by a large company in the Pittsburgh district for annealing bright strip steel, and it is guaranteed that the steel will come out of the furnace as bright as it went in. The following list is given of some of the uses to which furnaces of this type have been put: Annealing steel castings and car axles, heat treating steel castings and shells, carbonising, annealing aluminium, copper and brass, and melting copper, brass, aluminium and silver. To these will be added shortly, electric soaking pit furnaces for steel plants and rivet furnaces for structural and bridge shops, as well as the car type of annealing furnaces, continuous pusher type furnaces, automatic heat-treating furnaces, and brass melting furnaces. In the use of the electric furnace for melting non-ferrous metals the tilting type is the one offering the greatest saving in cost over fuel-fired furnaces of any type; as the metal loss is lower, the crucible cost is eliminated, and the labour item is low. It is stated that the following figures may be taken as working conditions in melting yellow brass in a plant operated 24 hours a day:—Electricity 400 kw.-hrs. per ton at ½d., 16s. 8d. per ton; metal loss, 1 per cent. zinc at 5d. per lb., 8s. 4d.; labour, one man per hour per 600-lbs. at 1s. 8d. per hour, 5s.; total cost per ton of metal, £1 10s.

Improvements in Ingot Moulds.

Sir W. G. Armstrong, Whitworth & Company, Limited, Newcastle-on-Tyne, have recently acquired patent rights for an improved construction of heavy ingot moulds, more particularly for dealing with heavy ingots whose weight may reach 100 tons or more. It is claimed that with the moulds as formerly made the heat is not extracted sufficiently quickly from the liquid mass, that by this new process of promoting solidification, segregation is prevented from taking place in the greater part of the ingot, and that, in addition to a much superior quality of steel being obtained, the risk of corner cracking is reduced to a minimum.

Our illustration (Fig. 1) shows one of the usual form of octagonal moulds, together with the bottom plate. The improvement, however, is applicable to any other type of mould and bottom plate, as also to ingots which can be bottom-cast, or cast in clusters, whilst the mould or plate cooled may be used independently. In order to effect the necessary quick cooling, a cooling medium is circulated within the walls of the mould and bottom plate.

Referring to the illustration, within the walls of the mould A, the encased circulating point is shown at D, whilst the inflow is effected at E, and the discharge at F, the feeding head being indicated at C. When dealing with the heavy ingots referred to, some of which may assume a considerable length, provision is made for the inflow and discharge of the cooling media at intervals in the length of the mould (Fig. 2), in order to more quickly cool any desired portion of the liquid metal, and at the same time maintain any other portions of the mould at any required temperature. For this purpose the piping is divided into independently controlled sections, so that the cooling media may be supplied to any section of the mould; an independent section of pipe is also provided in the base of the mould. The cooling medium is controlled by means of cocks E and discharged from the pipes through F.

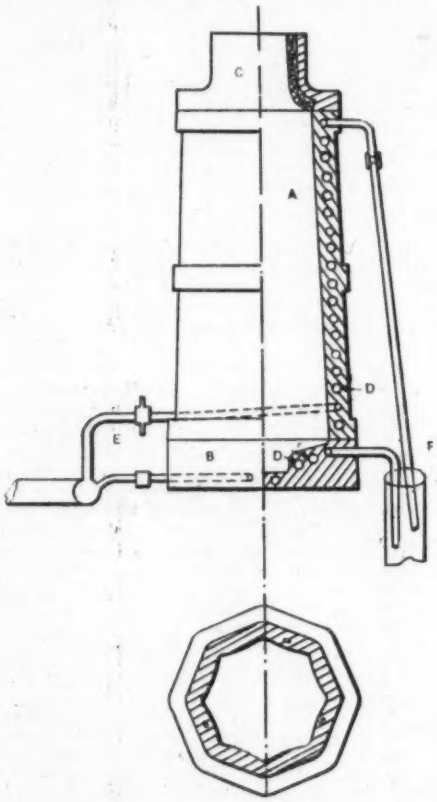

Fig. 1.

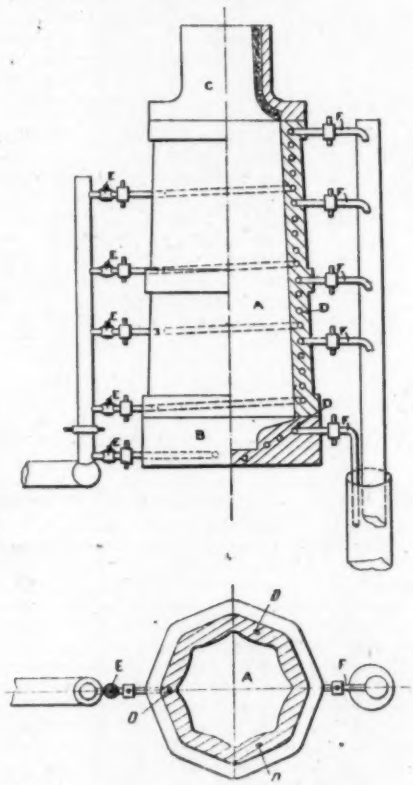

Fig. 2.

Improved Type of Ingot Mould.

It will thus be seen that by opening only the lowest cock, E, the bottom plate alone is cooled, and similarly any section of the mould may be cooled as desired. It will be obvious that an additional advantage of this method of cooling from within the walls of the mould is that the latter is maintained at a comparatively low temperature, and the effect of this, together with the strengthening of the cooling encasement, adds considerably to the life of the mould.

The system has distinct advantages over the forms of outside cooling which are occasionally employed, as with the latter, in addition to the risk incidental to the use of water, the life of the mould must be adversely affected by the heavy stresses set up due to the great differences of temperature between the inside and outside faces of the mould.

Silica Refractories.

In a Paper read at a recent meeting in New York of the American Institute of Mining Engineers, Mr. J. Spotts McDowell, of the Research Department, Harbison-Walker Refractories Company, Pittsburgh, submits the results of an investigation which he describes as a continuation of one begun by Mr. Kenneth Seaver, chief engineer of that company. Remarking that the magnitude of the thermal expansion of silica brick, and its inability to withstand rapid temperature changes, present problems of considerable importance in the manufacture of siliceous refractories, the author proceeds to devote the earlier portion of his Paper to the study of data compiled from various publications. He then passes on to deal with the results of experiments conducted with test bricks of silica, which were made under conditions devised with the purpose of studying the effects of variations in grind and temperature of burning, and of repeated burning, upon their physical properties and constitution. Accordingly, three lots of 9-in. bricks (approximately 9 by 4½ by 2½ in. in size) were made up and designated as "regular," "medium," and "fine grind" respectively. The regular-grind specimens were made by the usual method for 9-in. bricks; those of medium grind were given the grind used for silica shapes and pounded into loose side moulds, as silica shapes are treated. The material used for the fine grind was screened through an 8-mesh hand screen, returned to the pan and reground long enough to add and mix lime thoroughly; the bricks were pounded into loose-side moulds. Screen analyses are shown in Table I.

Table I.—*Screen Analyses of Test Bricks.*

Grind.	Screen numbers in meshes per linear inch.					
	Held on					Through
	8 per cent.	16 per cent.	20 per cent.	30 per cent.	40 per cent	40 per cent.
Regular	15.3	13.4	4.6	5.4	4.8	56.5
Medium or shape ..	10.2	13.1	2.2	5.0	4.7	64.8
Fine	—	14.3	4.1	6.5	4.1	71.0

A number of bricks from each lot were burned under the ordinary conditions of manufacture at three positions in the kiln, designated for convenience as positions A, B and C. The bricks were burned a number of times, being under fire approximately ten days each time, and specimens were set aside for study after each burning. The temperatures attained on the various burns were measured by Orton-Seger cones, and varied from 1,390 to 1,450 deg. C.

In the transverse tests the bricks were laid edgewise with a span of 6 in. and the load applied at midspan. Modulus of rupture was calculated from the formula $R = \frac{3\,Wl}{2\,bd^2}$, in which l is the distance between supports in inches, b the breadth and d the depth of the specimen in inches, and W the load in pounds at which failure occurred. The crushing strength was obtained by dividing the crushing load in pounds by the mean area in square inches of the two surfaces of the brick. The results obtained are given in Table II.

Table II.—*Sample Log and Data Sheet; Cross-Breaking and Crushing Tests.*

Cross-breaking span, 6 in.

Breadth of brick, In.	Depth of brick, In.	*W*	*R*	Mean *R*
2.48	4.45	4,970	910	920
2.46	4.45	4.820	890	
2.52	4.43	5.260	960	
2.66	4.73	7.010	1,060	1,050
2.66	4.71	7.450	1,140	
2.68	4.71	6.320	960	

Crushing: Half brick crushed flat.

Crushing area, sq. in.			*W*	*C*	Mean *C*
1	2	Mean.			
19.80	17.58	18.69	51,900	2.780	2,680
19.54	17.97	18.75	45,600	2,430	
16.46	16.16	16.31	46,100	2,830	
21.75	21.33	21.54	101,000	4,690	4,780
21.18	20.24	20.71	120,500	5.820	
20.26	20.00	20.13	77,000	3,830	

W = Load causing failure in lbs.
R = Modulus of rupture, lbs. per sq. in.
C = Compressive strength, lbs. per sq. in.

Uniformity of strength of a given lot of bricks diminishes with repeated burning; slightly in compression, considerably in cross-breaking. The most uniform bricks are those of regular grind; fine-grind bricks are fairly uniform in crushing, very non-uniform in cross-breaking strength. The figures indicate that the medium-grind brick is the most satisfactory in point of strength, the regular grind least so. While the compressive strength of the medium grind is somewhat lower than that of the fine grind, its cross-breaking strength is greater and it is a much more uniform material. In cross-breaking, the fine grind shows little if any advantage over the regular grind, for while its mean

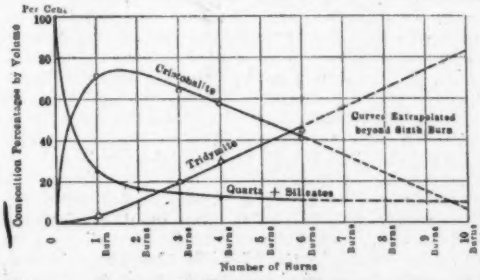

Fig. 1.—Effect of Repeated Burning upon the Constitution of Silica Bricks. Burning Temperature, 1,410 to 1,430 deg. C.

strength is high, it lacks uniformity; in compression, it is far stronger than the regular grind.

There is, in all cases, an advantage in burning the bricks a second time; for the medium and fine grinds a third burn is usually harmful, decreasing the cross-breaking strength considerably and increasing the compressive strength very slightly. Bricks of regular grind increase in strength on each burn up to the third, slightly in compression, con-

siderably in cross-breaking. The alternate expansions and contractions incurred in repeated burning may tend to cause the formation of minute cracks in the bricks and to have an unfavourable effect upon their strength. For that reason it is probable that stronger bricks would be produced by maintaining the maximum temperature a greater length of time during a single burn than by resorting to repeated burning.

The effect of repeated burning on the constitution of bricks of regular grind, burned several times, is shown in Fig. I. The analyses after repeated burnings are shown in Table III.

TABLE III.

Mineral.	Number of burns			
	1	3	4	6
	Vol. %	Vol. %	Vol. %	Vol. %
Quartz (+Silicates) ..	25	14	12	14
Cristobalite	71	64	58	42
Tridymite	4	20	30	44

It is evident that in the first burn the larger part of the quartz is transformed into cristobalite, and that on repeated burning the remaining quartz is very slowly transformed. The cristobalite at first very slowly, and later more rapidly, inverts to tridymite. Time and temperature of burning appear to be the controlling factors. Bricks burned a single time at 1,410 to 1,430 deg. C. show essentially the same amount of transformation. those burned at 1,390 deg. C. show considerably less. The effect of variations in grind is comparatively slight.

Effect of Lime.—Fineness of grind is not the controlling factor in the formation of tridymite, since that mineral evidently forms nearly as rapidly in the bricks of coarse (or regular) grind, as in those of finer grinds. A seeming contradiction exists between this fact and the fact that the inversion to tridymite takes place more rapidly in the fine-grained ground-mass of the bricks than in the larger quartzite fragments. The relative concentrations of lime in the ground-mass of bricks of various grinds probably has some bearing in this connection. In the manufacture of the brick, 2 per cent. of lime is added to ground quartzite containing about 2 per cent. of impurities (mainly Al_2O_3 and Fe_2O_3). Since all this enters the ground-mass, the proportion of lime therein is much higher than 2 per cent. The greatest concentration of lime in the ground-mass will occur in those bricks with the least proportion of fines (*i.e.*, the regular grind) in which, therefore, conditions will be most favourable for the formation of flux compounds during the burning. The catalytic action of the flux compounds probably explains the observed inversion of cristobalite to tridymite, which does not form except in the presence of a flux. According to this point of view an increase in the amount of lime in the brick should accelerate the formation of tridymite.

The Phenomena of Expansion.—The permanent expansion of silica brick after the first burning (in which ± 5 per cent. of tridymite and ± 70 per cent. of cristobalite are formed) amounts to 10 to 11 per cent. by volume. The gradual decrease of quartz and increase of tridymite caused by repeated burning theoretically requires a slight additional expansion after each burn until equilibrium is reached, since the complete transformation of quartz to cristobalite is accompanied by a volume increase of 13.6 per cent.; quartz to tridymite, 16.8 per cent. At 1,250 deg. C. the specific volumes of cristobalite and tridymite are approximately 14 to 15 per cent. greater than that of quartz. Since the residual quartz of silica bricks gradually goes over into the other forms of silica at furnace temperatures, an underburned brick will expand considerably after being placed in use.

Tridymite expands upon heating much less than does cristobalite. Its specific volume at 20 deg. is 2.8 per cent. greater than that of cristobalite; at 1,000 deg., nearly the same as that of cristobalite. The gradual transformation of cristobalite into tridymite, shown to occur upon repeated burning of silica bricks, probably takes place also in furnace linings. This inversion is accompanied by little, if any, change in volume at furnace temperature.

For several reasons a large proportion of tridymite in silica bricks is desirable, provided the bricks are not to be heated continuously above 1,470 deg. C. (1) Tridymite has the least thermal or temporary expansion of the three silica minerals. (2) Tridymite has the greatest specific volume of the three minerals, and cannot show any permanent expansion after repeated burning below its melting point. (3) A tridymite brick could probably be subjected to fairly rapid changes of temperature with little danger of cracking.

Since the time element appears to be the most important factor in the formation of tridymite, it appears that long-continued burning at the proper temperatures should be more satisfactory than repeated burning. The maximum temperature is maintained 40 hrs. in the burning of silica bricks; maintaining this temperature for 2½ weeks should presumably give rise to the same changes in constitution as ten separate burnings under the ordinary conditions of manufacture, and produce brick consisting almost wholly of tridymite.

In order to make a brick containing the maximum proportion of tridymite, the burning temperature should be that at which the inversion to that mineral proceeds most rapidly. It appears that this must occur below 1,470 deg., since tridymite is not known to form under any conditions above that point.

Spalling Tests.—A relation probably exists between the amount of cristobalite in a silica brick and its tendency to spall upon rapid change of temperature, and since the percentage of cristobalite decreases on repeated burning the spalling tendency should likewise diminish. A test was carried out as follows:—The bricks to be subjected to the heat treatment were placed in a gas-fired test kiln, sixteen at a time, and heated at a uniform rate of 15 deg. C. per hour (so as to cause no injury to the specimens during the heating) until 600 deg. C. was attained. They were kept at that temperature for 3 hrs., and at the end of that time were withdrawn and placed on edge on inverted steel pallets about 2 ft. apart, in a place protected from drafts, and allowed to cool in the air of the laboratory. They were not moved until the following day. This treatment had the desired effect.

STEEL-HARDENED CASTINGS.—The Stroh process, as carried on by the Stroh Steel Hardening Process Company, of Pittsburgh, is a method for casting the finest alloy steel together with ordinary soft steel in one solid piece. The resultant casting has a wearproof stratum on the wearing surfaces. A number of Stroh products are used in the mining industry—mine car wheels, mill castings, crusher heads, crusher jaws, etc.

Machinable Castings from Permanent Moulds.*

By Alexander E. Outerbridge, Jun.

The importance of having some simple, cheap and reliable method of changing the physical properties of molten iron after it has been tapped from the cupola has been regarded as a desideratum ever since the value of the method of modifying the chilling property of car-wheel iron in individual ladles, by treatment with powdered ferromanganese, became well known. A great many experiments were made by me in 1880-4 with aluminium, spiegeleisen, and 80 per cent. ferromanganese, granulated or powdered, added in small quantity to the metal in the ladles.

The effects produced by aluminium and spiegeleisen were in the right direction, though they were not sufficiently marked to be valuable, but it was then found that when powdered 80-per cent. ferromanganese was added in the proportion of 1 lb. to 600 lbs. of iron in a ladle, a most remarkable change was immediately produced in the character of the molten iron in the ladle. The transverse strength of the metal (high chilling iron) was increased from 30 to 40 per cent., the shrinkage was decreased from 20 to 30 per cent., and the depth of the chill was decreased about 25 per cent., while one-half of the combined carbon was changed into free carbon.

Prior to this time, manganese had always been regarded as a hardening element in cast iron, and the surprising claim that, when added in a ladle of high chilling car-wheel iron it had an opposite effect, at first met with incredulity, but in course of time its use became almost universal and I believe it still is used very largely indeed in the manufacture of chilled cast-iron car wheels.

The addition of a small quantity of the powdered 50 per cent. ferrosilicon alloy in a ladle of molten foundry iron produces a remarkable effect upon it, by softening and at the same time strengthening the iron. This is quite an opposite effect to that produced by increasing silicon in the cupola, which always tends to weaken iron.

Here we have, I think, a practical solution of one great difficulty that has heretofore militated against the successful use of permanent iron moulds for making castings that must be machined. A mere "skin chill" not thicker than a piece of tissue paper makes the surface of a casting too hard to machine, but by this simple process the foundry foreman can eliminate the last trace of chill from his metal before pouring it into an iron mould.

For years past more or less encouraging efforts have been made and described in technical journals of methods for making castings in permanent iron moulds. The most ambitious one, perhaps, was the pipe casting process of Mr. Custer at Tacony, Pa., a few years ago, for which he obtained several patents. Mr. Custer ingeniously overcame the trouble from skin chill on his castings by turning them out of the moulds before the molecules had taken a final set and the intense heat in the body of the casting helped to anneal out any skin chill that might have formed. Mr. Custer failed, unfortunately, to take into due consideration the fact that grey cast iron, of which his moulds were made, "grows" or increases in cubical dimensions when repeatedly heated above a certain point and then cooled. This, I am informed, caused such a rapid deterioration of his casting machines that his process proved a failure and has been discontinued.

Ever since 1888 machinable castings have been made in the foundry of Wm. Sellers & Company, Inc., Philadelphia, in permanent iron moulds and still are being so made. In fact, more than 100 permanent iron moulds, ranging in weight from a few pounds up to 7,000 lbs. each, are to be found in use in this foundry.

The main object of casting in iron moulds is to secure machinable castings of exceedingly fine grain, free from dirt, sponginess or other defects, while at the same time having marked increase in strength. The question of relative cost of castings made in permanent iron moulds (eliminating the moulder entirely) as compared with similar castings made in green sand, or in dry-sand moulds, depends upon the number of machinable castings required to be made from one pattern as well as upon other conditions.

In the year 1880 I suggested to the foreman of the car-wheel foundry of A. Whitney & Sons, Philadelphia, with which I had become connected as metallurgist, the idea of casting all the "over-iron" in iron moulds instead of in open sand moulds, thus giving more room on the foundry floor and avoiding expense of making up a sand pig bed daily. The foreman exclaimed in alarm, "Why it will be all white iron, and when we remelt it with the wheel mixture the next day the wheels will all be too hard. We do use a little white iron sometimes to bring up the chill when the mixture is running down in chill, but this plan would spoil all our calculations."

Nothing but an actual demonstration would convince the man of his error. Iron pig moulds were then ordered to be made and a ton of regular wheel iron cast therein. This iron was, of course, white. On the next day the ton of white iron was remelted in a small cupola without any admixture and cast into test bars, chill test pieces and two test wheels. On the following day, when all of these were broken, instead of being white iron, as the foreman had predicted, there was no appreciable difference found between the castings made from iron that had been chilled white in the iron moulds and similar castings made from the same iron cast in sand moulds.

On coming to the establishment of Wm. Sellers & Company, Inc., in March, 1888, I found the same conditions and immediately substituted iron pig moulds, which have been used daily ever since that time. These iron moulds, for over-iron, anticipated by many years the machine-cast pig-iron process now so generally used, and naturally led to the next step, namely, making permanent iron moulds for castings, as soon as it was found practicable to prevent iron poured in them from being too hard to readily machine. As to how these moulds are prevented from warping or growing so as to become useless, there are two distinct methods. The simplest method and the one we adopt is to make but one casting from one melt in one iron mould. In this way the mould never gets red hot and so it does not grow. The second method is to use low-silicon iron for the moulds, as metal of that character grows far less when repeatedly heated and cooled above a cherry red than does soft foundry iron. Finally I may say that castings made of white iron do not expand permanently when heated and cooled sufficiently to overcome the original shrinkage of the metal, so that when practicable permanent iron moulds may be made of white iron.

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* Abstract of Paper read before the Philadelphia Foundrymen's Association.

British Decimal Coinage: A Choice of Unit.

By Harry Allcock, M.I.E.E.*

The advantages to be derived from our adoption of decimal coinage are now generally admitted, but there is some divergence of opinion on the question of the best monetary unit for a British system. The £ sterling is our present unit, and national sentiment demands its retention if possible; but as this would involve certain difficulties, a few comments thereon may be of interest.

In the first place, we find that, since the hundredth part of a sovereign (viz., 2.4 pence) is too high in value for our smallest coin, all less values would have to be expressed as thousandths of a £, involving the use of *three* figures after the decimal point. No other first-class nation employs more than *two* figures after the decimal point. This difficulty gave rise to the advocacy of the florin as the unit. As the florin is exactly one-tenth of a £, it follows that the coin representing one-hundredth of a florin (and therefore expressed by the second figure after the decimal point) has precisely the same value as that representing one-thousandth part of a £.

Alternatively, retaining the £ as our unit, our three cash columns might be rechristened, £, florins, mils (instead of £ s. d.), but this would mean the surrender of one of the advantages of decimal coinage, viz., the ability to express any sum of money in two columns. To illustrate these points we may note that the following alternative expressions would represent equal values :—

£1.275 = Flo. 12.75 = £1 2f. 75m.

We are next confronted by the fact that one-thousandth part of a £ (£.001, or 1 mil) is equal to 0.24d., i.e., 4 per cent. less than our present farthing. This means that the retention of the £ as our monetary unit would necessarily involve an alteration in the *values* of all our bronze coins. Although this slight alteration may appear trifling, we must remember that it has been the chief stumbling block in all previous attempts to introduce decimal coinage into this country. If we chose the 4-mil piece as our new penny, we should have the awkward factor of 12½ such pence to the shilling, and if we adopted the 5-mil piece our new penny would have a value 20 per cent. higher than our present penny. In either case new bronze coins would be required, and, apart from all normal difficulties incidental to such a step, it will be obvious that no such change would be possible until such time as the necessary supplies for metals, etc., could be obtained on reasonable terms. This postponement would prevent us from taking advantage of the present most opportune time for introducing decimal coinage.

The retention of our £ sterling as our monetary unit has the further disadvantage of making it difficult for us to achieve the desired uniformity of coinage throughout the British Empire. On this point we should bear in mind that the Dominions Royal Commission, in their Final Report, dated March, 1917, recommended :—

> "713.—We are of opinion that the termination of the war will bring with it an unequalled opportunity for securing this much-needed reform, and we recommend that your Majesty's Government and the Governments of the Overseas Dominions should then co-operate to establish throughout the Empire a uniform coinage based on the decimal system and uniform weights and measures based on the metric system."

Such uniformity would be possible on the dollar basis, but difficult, if not impossible, on the £ basis, because of the exceptionally high value of the £ as compared with all other monetary units. Parts of the Empire, e.g., Canada and Newfoundland, have already discarded the £ sterling in favour of the dollar, and are not likely to revert to the £. Further reference to this consideration is made below.

Appreciating these difficulties, let us consider the merits of an alternative monetary unit. Given an unfettered choice, the best monetary unit for a decimal system of coinage in any country is a coin having a value equal to 100 times that of the smallest coin in common use. Applying this definition to the United Kingdom, we should have :—

100 × ¼d. = a British dollar of 4s. 2d.

Such a unit would be practically equivalent in value to the gold dollar already in use in the U.S.A., Canada, Newfoundland, and most of South America. Although the value of this unit might be considered very small by reason of its representing only about one-fifth of our present £ sterling, it should be appreciated that it would nevertheless be equal to about twice that of the Russian rouble or Japanese yen, three times that of the rupee, four times that of the mark, and five times that of the franc.

Apart from the well-known advantages to be derived from our adoption of a decimal system of coinage, it will be apparent that our selection of the above-mentioned British dollar as our unit would assist in bringing about the ultimate adoption of one universal system of decimal coinage for use not only in the entire British Empire, but also throughout the English-speaking world. The entry of the United States into the war provides a stimulus for joint action to secure this boon. The following table gives in capital letters the complete set of new British decimal coins, and also, in small type, the full range of our existing coins with their exact values expressed in British dollars and cents :—

Description.		Cash entry.			
		Existing coins.		New coins.	
		Dollars.	Cents.	Dollars.	Cents.
Gold or Notes	5 Dollars ..	—	—	5	00
	Sovereign	4	80	—	—
	2½ Dollars ..	—	—	2	50
	½-Sovereign ..	2	40	—	—
Silver	1 Dollar	—	—	1	00
	Half-crown ..	—	60	—	—
	½-Dollar	—	—	—	50
	Florin	—	48	—	—
	¼-Dollar	—	—	—	25
	Shilling	—	24	—	—
	Sixpence	—	12	—	—
	10-Cents ..	—	—	—	10
	3d. piece ..	—	06	—	—
Nickel	5-Cents	—	—	—	05
Bronze	Penny	—	02	—	—
	Half-penny ..	—	01	—	—
	Farthing	—	005	—	—

This table shows that we could proceed forthwith to keep all our accounts and conduct all our trade in British dollars and cents, and thus reap many of the benefits of decimal coinage without waiting for the minting of new coins and without altering the value of any coin now in use. The purchase of metal for the new coinage, the minting of new

* "Radbourne," Hale, Cheshire.

coins, and the date or dates of issuing such new coins could be deferred until after the war, when it is important to note that any or all of the new coins could be used simultaneously with our existing coins without loss to the individual or to the State. In the course of time, as the use of the new decimal coins became established, the old coins could be gradually withdrawn and re-minted on the new basis.

It will be seen that every sum of money now expressed in £. s. d. could be exactly expressed in British dollars and cents by reducing it to half-pence and placing the decimal point to the left of the last two figures, thus :—

£	s.	d.		Dollars.	Cents
	18	11½	=	4	55
843	14	10	=	4,049	96
58,500,000	0	0	=	280,800,000	—

Incidentally, it will be noted that the above examples demonstrate that in the countless transactions of daily life less figures would be required in our accounts, and the time spent, together with the risk of error, would thus be enormously reduced. For instance, a shopping account including a number of items of the order of the first example would only require half the number of figures, and their total would be arrived at by simple instead of compound arithmetic.

It would appear from the above review of the situation that, while the relatively few who are concerned in high financial operations would naturally prefer to retain the £ sterling, there is much to be said for the alternative basis herein described when considering the general convenience of the community at large. If it is felt that the retention of the £ sterling is necessary for purposes of international finance, there is no reason why it should not survive for that special purpose. We still speak of guineas, although it is many years since guinea coins were withdrawn from circulation, and the £ sterling could be entered as 4.80 British dollars just as we now express the guinea as £1 1s.

If the difficulties referred to in the opening part of this article could be satisfactorily overcome there would, of course, be no necessity for us to consider the merits of any alternative unit. But, on the other hand, if those difficulties are considered insuperable, the demand for decimal coinage could be satisfied without further delay by our adoption of the British dollar as the monetary unit.

Technical Education in France.

M. Leon Guillet, Professor at the Conservatoire National des Arts et Métiers and the Ecole Centrale, both famous centres of learning, a short time ago delivered a lecture before the Society of Civil Engineers of France, in which, after reviewing higher technical education in France, Germany, Belgium, Switzerland, England and the United States, he laid before his hearers certain suggestions for reforming the system of technical education now in vogue in his own country. The conclusions arrived at by him are briefly as follows :—

(A) As regards the preparation for the highest-grade schools : (1) The study of the classics is useful. Hence those who have studied them should enjoy some advantages. (2) The teaching of experimental sciences is to be modified. (3) The special classes for mathematics, the present bugbear of so many candidates, might be abolished; the teaching of mathematics should form part of the syllabus of study during a preparatory year. (4) Admission to the highest-grade schools should be by examination, including elementary mathematics. (5) The age limit of pupils should be reduced considerably, a matter of great importance. (6) After a preparatory year at the school, a rigorous weeding out (up to 50 per cent. if necessary) of the candidates who do not give any promise for the future. (7) The syllabus of study during the preparatory year should be so arranged that students who fail may enter institutions of the rank of Universities, or other paths of studies.

In connection with (3) M. Guillet quoted a passage from a statement once made by M. Haton de la Goupillère, the famous ex-professor of mathematics at the School of Mines and at the Sorbonne, that he had cut down the time spent on teaching the differential and integral calculus to ten lessons, into which he had carefully condensed all that his pupils required, in his opinion, to help them through the rest of their studies. As regards (5) it should be explained that French engineers now enter upon their professional career between the ages of 25 and 27, while everywhere else their colleagues enter the shop at the age of 22 to 24, because the young Frenchman has to serve two or three years in the army, while the young German engineer only serves one year, and probably is often exempt altogether.

(B) As regards the Technical School itself, M. Guillet's recommendations are :—(1) Maintenance of strict discipline. (2) A slight relaxing of examinations. (3) Individual efforts and initiative should be encouraged by all possible means. (4) Professors should only be chosen from among men in actual practice in the branch of the industry they are teaching. (5) The teaching should be encyclopædic, comprising everything that must be known by a certain category of engineers. (6) Less teaching of theory, and in its place more of generalisation in the study of industrial sciences. (7) More practical work carried on by the pupils individually instead of pupils watching in groups someone else. (8) More "documents" in the shape of a brief written outline of the lessons to guide pupils in their studies; plans of modern workshops, workshop and test room fittings; "economic" documents, such as computation of cost of production, list of selling prices, statistics (output, consumption, exports of principal countries), customs, tariffs, etc.; test-sheets, specifications. (9) Absolute necessity of pupils working as improvers, of visits to works and journeys for educational purposes. (10) Establishment, if possible, of centres of specialised education by the Universities. (11) The very interesting employment of the cinematograph in the teaching of the higher branches of technical science. (12) The real need of higher-grade teaching centres for "old boys."

Although some of these proposals may appear to be of a revolutionary character, Professor Guillet has already adopted them in his own classes. As regards cinematograph films for teaching, the only objection to them is their great cost, but the author has been able to make arrangements with the Gaumont firm satisfactory to both parties to the agreement. Some of the views selected were :—(1) The charging of a blast furnace in the old-fashioned and the modern way. (2) The manufacture of zinc from the ore through all its stages to the refined metal in crucibles. (3) Modern methods of testing metals by tension and shock.

Correspondence.

The Effect of Silicon in Cast Iron.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With regard to this controversy, which I have followed with great interest, I should like to put in a plea for more precise and comprehensible language. As you have already remarked, neither of these gentlemen has indicated clearly what he meant by control. This and various other points of uncertainty make it very difficult for the ordinary reader to make out what they are discussing. Mr. Adamson, on the one hand, is given to loose and general statements which might mean anything or nothing, while Mr. Rolfe, on the other hand, has adopted the scientists' method of making non-committal statements, which leave one in doubt as to their precise meaning. Although nothing like so bad, he tends to go the way of the doctor who told an unfortunate patient he was suffering from exacerbated hyperæmia of the cornea, meaning his eye was bloodshot.

So far as I can see, the point these gentlemen have talked round is the question of the *relative* part played by silicon in the variation of the different physical properties of cast iron. The actual point itself they seem to have fought shy of as being an "academic discussion."

Undoubtedly, carbon is the element which plays the principal part in cast iron. The relative amounts of combined and graphitic carbon are considered to be of great importance in the production of a good iron.

The combined carbon exists as a hard and strong compound, and large quantities of it make a hard, strong iron, such as white iron. Graphite exists as thin flakes distributed through the mass of the metal. On the size of these flakes depends largely whether the iron is open or close grained, large flakes producing the former.

Silicon has a slight direct hardening effect, which is more than counterbalanced by its indirect softening effect due to the fact that silicon tends to convert carbon to the graphitic form. Hence high silicon tends to produce a grey iron. This effect, however, may be entirely neutralised by the presence of sufficient sulphur. Sulphur tends to keep carbon in the combined state and helps to produce a white iron. Manganese neutralises the effect of sulphur to a certain extent, and so in an iron with a high sulphur has a softening effect. Phosphorus makes cast iron fluid, and is liable to give it a more crystalline fracture.

Rapid cooling from high temperatures at which all the carbon is in solution, does not give the carbon time to turn to graphite, and so produces a white iron. Suitable annealing has the opposite effect, and makes a greyer iron. It will be seen that it would be folly to say either that silicon does or does not "control" iron. Silicon certainly does have a strong influence on the carbon distribution of cast iron *in certain circumstances.*

The true chemist does not limit himself either to physical or analytical tests, but requires to know something about both before he can say anything about a particular iron.

With regard to the question of grading by silicon content, Mr. Adamson very properly condemns it as often unpractical. It would, however, be a satisfactory method if due notice were taken of the sulphur, manganese, and phosphorus contents as well as the conditions of production. This would complicate matters to an extent which is rather undesirable.—Yours, etc.,

AJAX.

To the Editor of the FOUNDRY TRADES JOURNAL.

SIR,—Your comments in the August issue on this correspondence have made it quite unnecessary for me to reply to Mr. Rolfe's letter in the same issue. The only reply I would have made would have been to refer to the last sentence in his letter, which indicates a lack of understanding of blast-furnace practice; otherwise he would have understood your rendering—which, I believe, is also mine—of the term "heredity" in pig iron.

Yours, etc.,

Sheffield, E. ADAMSON.
August 13, 1917.

To the Editor of the FOUNDRY TRADES JOURNAL.

SIR,—I have read with considerable interest and a good deal of agreement your editorial contribution to the above discussion. There is one point, however, on which I venture to make a few comments, and that is with regard to the meaning I have attached to the word "control." I have been using this word as practically synonymous with "influence." You do not agree with this, and suggest that an influence can be conditional, but a control must be positive. With due deference to your opinion, however, I submit that this rendering is not commonly accepted. If it were, one could not qualify the word in the way often done, as, for example, one might speak of the "limited control" exercised by a Food Controller. By your interpretation he would either control or not control. I suggest that he would and does partially control.

As regards the meaning of the word control, I sought to discover (see my note on pp. 193 and 194) what Mr. Adamson meant by it; and suggested that if he meant one thing, I agreed, but if he meant the other, I did not. I have elaborated this almost *ad nauseam.* He has since written two letters, and has thus had two chances of saying that he agreed or disagreed with either of my renderings of his meaning, but he has not done so. I am thus still quite in the dark as to precisely what he considers is the effect of silicon. I am for the moment, however, quite willing to accept your definition that a control ("a power to govern") must be positive, in which case, as you rightly observe on p. 406, no constituent controls the properties of cast iron. This incidentally renders a good deal of what Mr. Adamson said about silicon in his first article something like flogging a dead horse.

I still maintain that Mr. Adamson does not attach sufficient importance to the influence of silicon in cast iron, and I am confirmed in this opinion on carefully re-reading his original articles. These suggest that its effect might almost be disregarded. Take, for example, the following sentence on p. 76:—"'It is possible to get practically the same tensile and transverse tests from 1 per cent. silicon, and from 3 per cent." This is quite true, but it is not a fair illustration of the effect of silicon. As has already been clearly demonstrated by Hatfield (see p. 193), other conditions being equal, the increase of silicon from 1 to 3 per cent. will convert a white iron into a grey. Again, this is a case where silicon content has certainly controlled the fracture.

Mr. Adamson says, however (p. 73): "Silicon content does not control the fracture of the pig-iron." Certainly it generally does not, but it *may*. Mr. Adamson makes too much of the case against silicon influence, while much neglecting the case for it. Perhaps he would be willing to re-state his original opinion (see p. 73) in the following manner:—

"Silicon content does not *control* combined carbon and its ratio to graphite, but often exercises a considerable effect thereon."

This has been practically the whole of my case, the effect of silicon on the carbon distribution. As I have just pointed out, however, Mr. Adamson's original statements need qualifying even as regards fracture.

Yours, etc.,
R. T. ROLFE,

Bedford, August 17, 1917.

A Munitions Council.

It is officially announced that, owing to the great increase in the staff and duties of the Ministry of Munitions, a "Munitions Council" is to be established consisting of the Minister of Munitions, the two Parliamentary Secretaries to the Ministry, and representatives of groups of departments. The following is the official statement on the subject:—

(1) In order that large questions of policy affecting all Departments may come before the Minister with the advice of a limited number of officers representing the whole Ministry and that questions affecting single Departments or groups of Departments may be speedily decided by the Minister or those to whom his authority may be delegated in accordance with his general policy, the following administrative changes have been approved:—

(2) A Council will be established, to be called the "Munitions Council." It will consist of the Minister as President, of the two Parliamentary Secretaries as Vice-Presidents, and of members each representing a group of the Departments of the Ministry, together with the secretary.

(3) The members sitting in Council will be representative of the Departments of the Ministry as a whole. The Council will consider such matters as may be referred to it by the Minister and any matters which may, with the Minister's approval, be brought before the Council by any member of the Council.

(4) The position of a member of the Council in relation to his group of Departments will be:—

(i.) To superintend generally the work of the group and to consider in the first instance all important questions upon which the head of the Department requires assistance or rulings, such as those which would previously have been submitted to the Minister or through the Parliamentary Secretaries, and either to decide on the Minister's behalf such questions, or to refer them to the Minister with a recommendation as to the decision.

(ii.) To exercise such administrative functions through the heads of Departments in his group as are necessary to ensure that the policy of the Minister is carried out.

(5) Under rules approved by the Minister, important questions involving more than one group of departments will be considered at committee meetings and conferences which the members of the Council representing the groups concerned will attend. Failing agreement between the members of the Council, the question will be referred officially to the Minister for decision.

(6) Heads of departments will continue to be responsible for the efficient administration of their departments, and the necessary executive action will be taken by them, but all important questions, particularly matters which may affect general policy or other departments or which from their magnitude or novelty require financial sanction will be referred by them to the member of the Council to which their group is attached. No change in the organisation of a department or in important members of the staff will be made without similar reference.

(7) The member or members of the Council concerned will generally be present at conferences held by the Minister with heads of departments, or with associations, public bodies, &c.

(8) The Secretary of the Ministry will be responsible for the general administration of the Council Secretariat.

(9) A Council Secretariat will be established consisting of an assistant secretary and secretarial officers for each of the groups of departments, with a sufficient office and registry staff.

(10) The foregoing will come into effect from August 20.

Groups of Departments under Members of Council.

F. *Finance.* Sir Herbert Hambling.
D. *Design.* Major-General the Hon. F. R. Bingham, C.B.
S. *Steel and Iron.* John Hunter, Esq.
M. *Materials, Etc.* Sir Ernest Moir, Bart.
X. *Explosives.* Sir Keith Price.
P. *Projectiles, Etc.* Sir James Stevenson, Bart.
G. *Guns.* Sir Glynn West.
E. *Engines.* Sir Arthur Duckham, K.C.B.
A. *Allies.* Sir Frederick Black, K.C.B. (Temporarily, Sir Charles Ellis, K.C.B.)
L. *Labour.* Sir Stephenson Kent, K.C.B.
S. *Secretariat.*

British Prohibited Exports.

The Proclamation, dated May 10, 1917, prohibiting the exportation from the United Kingdom of certain articles to certain destinations, as amended and added to by subsequent Orders of Council, has been further amended by making the following alterations to the Schedule to the same:—

(1) That the following headings should be deleted:—

(A) Castings, malleable, hematite iron

(A) Machinery, agricultural, including hand tools which can be used for agricultural purposes.

(2) That the following headings should be added:—

(A) Castings, malleable, hematite iron, the following:—Belt fasteners; Buckles; Builders' ironmongery; Chain fittings; Coat and hat hangers; Conduit fittings; Cycle fittings; Furniture fittings; Hinges; Horse clippers; Lamp fittings; Motor-cycle fittings; Pipe flanges; Spurs; Stove fittings; Tramway fittings.

(A) Machinery, agricultural, and component parts thereof, including hand tools which can be used for agricultural purposes

(B) Nozzles, metal, having an orifice less than 1½ in. in diameter.

(B) Valves, metal, of all descriptions; (c) Valves, gas, steam and water, not otherwise prohibited.

Workmen's Compensation Insurance.

The accident insurance companies have decided to increase by 10 per cent., as from September 1 next, the rates of premium for workmen's compensation insurance, with the exception of those for domestic servants, in view of the increase of 25 per cent. in the weekly benefits provided for by the Workmen's Compensation (War Addition) Act. The additional premium is intended to be on account of fresh liabilities incurred on and after September 1 next, when the Act is to come into operation, and the question of the incidence of the cost of the increase of 25 per cent. in the weekly payments already being made on September 1 is left to the discretion of the offices.

Trade Talk.

A WINDING-UP order has been made against the Vaughan Engineering Works, Limited, 22, Cross Street, Islington, London, N.

THE GLENGARNOCK IRON & STEEL COMPANY, LIMITED, is being voluntarily wound up, with Mr. H. J. Sillars, the secretary, as liquidator.

THE PEARLITE STEEL COMPANY, LIMITED, Sheffield, has put into operation a small Monometer oil-fired furnace for melting crucible steel.

HARLAND & WOLFF, LIMITED, of Belfast, are interested in a new wolfram smelting enterprise which has acquired a property in Burma.

THE estate of Mr. R. H. A. Holbech, of Farnborough, near Fenny Compton, is being surveyed on behalf of Guest, Keen & Nettlefolds, Limited.

MESSRS. GALLOWAYS, LIMITED, are extending the erecting shop at their Knott Mill Ironworks, and are also engaged upon a scheme for extending the foundry.

WE understand that a proposal is under discussion for the establishment in London of a central body for dealing with all metals exported by the Colonies to the Mother Country.

MESSRS. HARLAND & WOLFF are engaged in carrying out a scheme for the extension of their works at Greenock, and with that object in view have acquired a site on the Esplanade.

MESSRS. LUKE & SPENCER, LIMITED, are making extensive additions to their Broadheath, Manchester Works; these, when completed, will enable the company to double their present output of emery wheels.

MESSRS. HANDCOCK & DYKES, consulting engineers, 11, Victoria Street, Westminster, S.W.1, have taken Mr. A. P. Trotter into partnership as from October 1 next, when the style of the firm will be changed to Handcock, Dykes and Trotter.

THE COATS MACHINE TOOL COMPANY, LIMITED, announce that Palace Chambers, to which they had removed their offices from Caxton House, having also been commandeered by the War Department, their address is now Thanet House, Strand, London, W.C.2.

THE STAVELEY COAL AND IRON COMPANY, LIMITED, of Chesterfield, have removed their London offices from Caxton House, Tothill Street, Westminster, to 5 and 7, Old Queen Street, Westminster, S.W. 1, for the period of the war. Caxton House has been taken over by the Government.

MESSRS. T. H. WATSON & COMPANY, LIMITED, Sheffield, owners of the Greaves-Etchells electric steel furnace, have formed an American subsidiary company, which is to be known as the Electric Furnace Construction Company, and has offices at Finance Buildings, Philadelphia.

MESSRS. J. J. SMITHIES, iron and steel merchants, Baron Street and Livsey Street, Rochdale, advise us of an alteration in the style of the firm, to John James Smithies, Limited. The title of the branch establishment has also been changed from John Petrie to John Petrie (The Baum), Limited. Both firms are private limited companies only, Mr. N. H. Smithies being governing director of each.

THE provisional executive appointed by representative chemists employed in Sheffield and district has been for some weeks considering the basis, rules, and constitutions for the proposed National Association of Industrial Chemists. About one hundred chemists have already been declared full members. Communications should be addressed to the Committee, Bailey Street Schoolrooms, Sheffield.

THE announcement was made at the weekly meeting of the Mersey Docks and Harbour Board that an application had been made by Mr. J. J. O'Neill, on behalf of a new company called the Mersey Shipbuilding Company, Limited, for the renting of a portion of the old shipbuilding yard at Seacombe, which has been for many years lying idle. The negotiations of the Works Committee of the Board were approved.

STATEMENTS having been made which may lead to the belief that in omitting from the Munitions of War Bill the clause dealing with dilution of labour on private work, the Minister of Munitions proposes to modify the policy of dilution on war work, it is now officially intimated that the clause which was omitted from the Munitions Bill dealt only with the extension of dilution to civil work. The continuous and increased output of munitions will necessitate the greatest possible extension of dilution upon war work within the safeguards already provided.

MR. ISAAC BRADLEY, of T. and I. Bradley, Limited, Capponfield Furnaces, Bilston, having decided to retire from business, his shares in the company have been partly acquired by Mr. W. J. Foster, of the Darlaston Furnaces, who has for some years been a director of the company. With Mr. Foster are associated other new shareholders and directors. There appears to be no truth in the statement published in the Birmingham papers that it is proposed to erect a steel works in connection with the furnaces. Mr. Isaac Bradley, who has now reached an advanced age, and his family have been associated with the works for many years.

NEGOTIATIONS are reported to have been completed which will lead to the establishment of a new shipyard at Pallion, Sunderland. The site is the Pallion High Yard, belonging to Mr. Ernest Webster, and it has been acquired by a newly formed firm, of which Sir John Ellerman is understood to be the principal, while among others interested are Messrs. Gray, of Hartlepool. The site was formerly occupied as a shipyard by the late Mr. Oswald, but it has been vacant for many years, during which considerable alterations have been made by the laying in of railway sidings and in other ways to improve it for shipbuilding purposes. It is about 16 acres in extent, and has accommodation for four berths, on which large ships can be built, one being capable of taking a vessel over 600 ft. long.

In the House of Commons, recently, Mr. Boland asked the Minister of Munitions whether he applied to the College of Science in Dublin to learn if it had the necessary facilities for giving instruction in nickel and brass casting before he transferred men from Ireland to Sheffield; and whether he was aware that, in addition to the facilities provided at the College of Science in Dublin for instruction, work of this kind was actually being executed for the Government by a Dublin firm. MR. KELLAWAY (Parliamentary Secretary): I am informed that the facilities provided at Sheffield University, which specialises in the particular work for which the men were required to be trained, are unrivalled in the country, and that there are no equivalent facilities in Ireland. I am not aware that this particular metal has been supplied to the Ministry of Munitions by any Dublin firm.

THE new steelworks at Redcar, of Dorman, Long & Company, Limited, consist of a 400-ton mixer, 10 large steel furnaces, a cogging mill, and two large plate mills, the total cost being somewhere in the neighbourhood of two millions. Good progress is being made with these extensions. Already three furnaces are at work, and a fourth will be ready in a week or two. When completed these new steelworks will produce from 300,000 to 400,000 tons of steel per annum, bringing the total capacity of the combined concerns up to an annual output of 1,000,000 tons. The Redcar Works will put the company in a position to add steel plates to their already extensive list of manufactures. The property of Walker, Maynard & Company, Limited, when taken over by the company, consisted of six blast furnaces and a battery of by-product coke ovens. The furnaces had been blown out some time before. The coke ovens have been recently completed by the Tees Benzol Syndicate under the direction of the Ministry of Munitions, and are producing coke. Under the instructions of the Ministry certain of the furnaces were at once blown in to make hematite for France. They are now producing basic pig-iron, which is being used in the new steel furnaces. In order to produce the

whole of the pig-iron required it will be necessary to introduce great changes at these blast-furnaces. The question of how this is to be done is under consideration of the advisers of the Ministry of Munitions. Altogether 5,000 to 6,000 will find employment at these works when the present developments are completed. After very careful consideration the company have acquired about 800 acres of land in the immediate proximity of the works. On this they propose building cottages to house the workmen and their families. A beginning has already been made, and at present upwards of 300 houses are in course of construction.

Applications for Patents.

Barrow Hæmatite Steel Company and Butchart, A. M. Tundish for handling molten metal. 10,388. July 19.
Clark & Company, T. and C., and Baker, A. H. Preparing sand moulds from patterns. 10,605. July 24.
Coles, S. O., Cowper-. Process for rendering aluminium and its alloys more durable. 11,612. August 13.
Connolly, J. Crucible furnaces. 10,396. July 19.
Cornthwaite, H. and S. Manufacture of steel. 10,350. July 18.
Gillespie, A. E. Acid-resisting metal, and articles made thereof. 11102. August 1.
Harvey, L. C., and Morgan Crucible Company. Crucible melting furnaces. 11,856. August 17.
Heinz, E. J. Process for manufacturing coke for metallurgic, etc., purposes. 10,411. July 19.
Higginson, J. Process for treating or hardening, etc., in manufacture or treatment of steel. 11,139. August 2.
Hodson, F. S. Metallic alloys. 10,276. July 16.
Hudson, O. F., the Imperial Trust for the Encouragement of Scientific and Industrial Research, and the Institute of Metals. Process for protecting copper or its alloys from attack by atmospheres or liquids. 10,576. July 25.
Metals Disintegrating Co. Method of reducing metal to a finely-divided state. 11,523. August 10. (United States, August 26, '16.)
Metals Disintegrating Company. Reducing metal to a finely-divided state. 11,522. August 10. (United States, August 23, '16.)
Moore, W. T. Vegetable material for moulding. 11,153. August 2.
Morris, A. W. Machines for casting metal under pressure. 10,427. July 19.
Morris, A. W. Die casting or forging apparatus. 10,571. July 23.
Oubridge, W. A. Ring, etc., casting-machines. 11,383. Aug. 8.
Sahlin, A. Apparatus for removing or replacing covers or tops of ingot or slab pit furnaces, etc. 11,563. August 11.
Selas-Turner Company, and Turner, E. Rendering cast-iron malleable. 11,308. August 7.
Selas-Turner Company, and Turner, E. Gas and air, etc., regulators. 11,425. August 9.
Smith, H. Open and muffled furnaces or kilns for case-hardening or annealing metals, etc. 11,312. August 7. August 7.
Tooth, L. F., and Tucker, A. E. Manufacture of brass. 10,402. July 19.
Turner, E. Rendering cast-iron malleable. 11,308. August 7.
Watson, J. Solder for aluminium and its alloys. 10998. July 31.

Iron and Steel Institute.

As previously announced, the Autumn Meeting of the Iron and Steel Institute will be held at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, the 20th and 21st of September. The following is the official programme of proceedings:—

Thursday, September 20.

General meeting of members at 10.30 a.m., when scrutineers will be appointed for the examination of voting papers for election of new Members of the Institute, and a selection of Papers will be read and discussed. (Nos. 1, 4, 5, 9, 2.) At 1 p.m. the meeting will be adjourned.

Friday, September 21.

General meeting resumed at 10 a.m., when a further selection of Papers will be read and discussed. (Nos. 10, 6, 7, 3, 8.)

New Maximum Prices for Steel Scrap.

The Ministry of Munitions have issued, under date of August 28, the following new maximum prices for steel scrap

The proviso previously held good that the maximum prices did not apply to "the sale by a manufacturer of finished steel rolled from steel purchased by him." For instance, scrap from imported American steel was not subject to the maximum. This has now been altered, and the prices given below apply to all steel scrap, no matter what its origin. The price previously fixed for special handy heavy steel melting scrap suitable for crucible use and special short extra heavy steel turnings is cancelled. The following maximum prices now apply:—

(1) (*a*) Heavy steel melting scrap, £5 5s. per ton.

(*b*) Steel turnings and borings, £3 10s. per ton.

(*c*) Steel turnings and borings mixed with wrought iron or other material, £2 10s. per ton.

(*d*) All other classes of steel scrap, heavy or light, whether or not mixed with wrought iron or other material, £5 5s per ton.

(2) All these prices are free on rail or free in barge at the nearest convenient siding or wharf to the place where the scrap lies at the time of sale; the carriage at actual cost or at a fair average rate agreed between the seller and buyer may be charged to the buyer up to a maximum of 10s. per ton.

(3) To these prices a sum not exceeding 2½ per cent. on such prices may be added in the case of sales by recognised scrap merchants.

Special permits to purchase steel scrap sold with guaranteed analysis may be granted on application, but in no case will permits be granted for any such purchase at prices exceeding the following:—

Heavy steel melting scrap containing not over 0.04 per cent. phosphorus and sulphur, £6 5s. per ton.

Heavy steel melting scrap containing not over 0.05 per cent. phosphorus and sulphur, £6 per ton.

Brass Scrap.

The Ministry of Munitions announces that in future manufacturers will not be permitted to obtain supplies of brass turnings or borings of any kinds, or of brass scrap arising from the manufacture of munitions, from any source except the Ministry. The following letter has been sent by the Ministry to firms requiring supplies:—

Regarding your future requirements of scrap metals, will you please note that in future you will not be permitted to obtain supplies of brass turnings or borings of any kind, or brass scrap arising from the manufacture of munitions of war, from any source whatever except the Ministry. All inquiries regarding these must be sent to 8, Northumberland-avenue, London, W.C.2, and under reference A.M.2/S.

On receipt of your requisition, together with particulars of contracts against which you would require to use the material, we will, provided these are found to be in order, make you an allocation as early as possible.

In the event of your having any complaint to make, either as to shortage in weight or to the quality of the scrap or swarf, notification must be made by you to the consignor within three days after receipt of delivery, and all claims must be settled direct between the consignor and the consignee, as the Ministry will accept no responsibility whatever in regard to these.

No swarf or scrap must be smelted until all claims regarding same have been adjusted, and the consignor must be given the option of seeing the material re-weighed before the consignment in dispute is broken into, and the weight thus agreed shall be the weight invoiced to the Ministry by the consignor.

Personal.

THE late Mr. Alfred Davis, C.E., of Ladbroke Grove, Notting Hill, left £23,567.

SIR JAMES B. MARSHALL has been elected deputy-chairman of J. Samuel White & Company, Limited, of Cowes.

THE late Mr. S. Ingham, formerly in business as an engineer and ironfounder at Cromford, Derbyshire, left £2,321.

ESTATE of the gross value of £14,334 has been left by the late Mr. H. Whitehouse, edge tool maker, of Cannock

MR. PETER YOUNGSON B.Sc. (London), has been appointed lecturer in marine engineering at the Central Technical School, Liverpool.

THE gross value of the estate of the late Mr. Thomas Kennedy, hydraulic engineer and founder, Howard Street, Kilmarnock, is £19,051.

MR. JOHN WHARTON, proprietor of Wharton's Iron Foundry, Maryport, has been co-opted a member of the Maryport Urban District Council.

MR. W. H. ELLIS, a director of Messrs. John Brown & Co., Ltd., has been elected Master Cutler of Sheffield for the fourth year in succession.

LIEUT. COLIN KING, of the Border Regiment, who has been wounded, was formerly employed at the American works of Messrs. W. Jessop & Sons.

LIEUT. JOHN KINGSLEY CROSS, director of William Cross & Son, Ltd., engineers and ironfounders, West Bromwich, has been awarded the Military Cross.

THE late Mr. J. Roberts, manager of the Forest Iron and Steel Works, Treforest, left estate of the gross value of £5,516, of which £3,994 is net personalty.

ALDERMAN A. CATTELL, the Lord Mayor-elect of Sheffield, is a director and secretary of Messrs. Samuel Warren, Limited, of the Speedwell Steelworks.

MR. J. W. RYAN and Mr. A. G. Foster, departmental managers of Clayton & Shuttleworth, Limited, Lincoln, have been elected to seats on the board of the company.

MR. A MILLER, of Dunlop House, Barrow, has, owing to ill-health resigned his position as a director at Messrs. Vickers' Naval Construction Works, Barrow.

MR. THOMAS RAMSAY, son of Mr. J. W. Ramsay of the Phœnix Engineering Works, Whitehaven, has been gazetted Second-Lieutenant in the Northumberland Fusiliers.

MR. A. C. J. CHARLIER, managing director of the Pearlite Steel Company, Limited, has been elected first president of the National Association of Industrial Chemists.

MR. C. C. ALLINSON, son of Mr. C. Allinson, of Wheatley Brothers, Limited, Wheatsheaf Works, Sheffield, now holds a commission as second-lieutenant in the R.F.C.

THE late Mr. J. Corfield, general manager of Messrs. Dillwyn & Company, spelter manufacturers, Swansea, left estate of the gross value of £19,504, with net personalty £18,036.

CAPTAIN ROBERT SHERRIFFS COOPER, who has been wounded, was on the staff of Messrs. William Jacks & Company, 19, St. Vincent Place, Glasgow, before he joined the Colours.

MR. JOHN BARR, cashier of Vickers', Limited, has been elected director for the firm at Barrow, in succession to Mr Archibald Miller, who has resigned owing to ill-health.

MR. H. T. DOBBS, for many years deputy locomotive engineer to the Barry Railway Company, has taken up duties in the Midlands, at the invitation of a Government department.

THE late Mr. J. M. Rennoldson, head of the firm of Joseph Rennoldson & Sons, Limited, engineers and shipbuilders, left estate valued at £68,483 3s. 7d., with net personalty £53,177 17s. 11d.

THE late Mr. H. E. Marples, a director of Wm. Marples & Company, Limited, and of Turner, Naylor & Company, Limited, edge and engineers' tool manufacturers, of Sheffield, left £31,730.

THE late Captain William Nixon, naval architect, formerly with the Blyth Shipbuilding Company, and afterwards with Messrs. Workman, Clark & Company, Belfast, left estate valued at £3,015.

THE late Sir Charles Holcroft left estate of the gross value of £1,599,677, and net personalty £1,463,897. He bequeathed £5,000 to Birmingham University to establish a Charles Holcroft Research Fund.

MR. ALBERT WRIGHT, of Redcar, manager of the shell plant at Messrs. Bolckow, Vaughan & Company's Cleveland Steelworks, has been the recipient of a presentation from the officials and workmen on leaving the district to take up an important position in South Wales.

SIR THOMAS MUNRO, County Clerk of Lanarkshire, has accepted the position of Chief Director in the Labour Regulation Department of the Ministry of Munitions in order to supervise the work in connection with general labour matters affecting wages and disputes, and, in particular, the formation as soon as possible of representative committees of employers and workpeople.

MR. T. W. CHERRY has been appointed representative for Cammell, Laird & Company, Limited, in the North-East Coast district, which position was previously held by the late Mr. Joseph Johnson. For the past few years he has been with John Rogerson & Company, Limited, of Wolsingham, as outside manager and representative on the North-East Coast. Messrs. Cammell, Laird's offices are at 32, Grainger Street West, Newcastle-on-Tyne.

JUVENILE LABOUR AFTER WAR.—In their report of the conference between the various juvenile employment bodies on the problem of employment after the war, the Ministry of Labour state that considerable discussion arose as regards the necessity for approaching employers with a view to inducing them:—(a) To notify discharges of juveniles in advance. (b) To notify all vacancies to juvenile employment committees during the period of demobilisation, and (c) To consider and formulate schemes of apprenticeship and training. It was felt that some arrangement should be made to prevent the children from wandering from one employer to another in search of work. It was decided that the London (Central) Advisory Committee should approach the Ministry of Munitions, the Reconstruction Committee of the Cabinet, the Ministry of Labour, and possibly the Board of Trade, in connection with the above matters. The question of asking for compulsion in connection with the notification of discharges and of vacancies was vigorously discussed, but the conference was not generally in favour of seeking compulsory powers. On the question of apprenticeship and schemes of training, no final decision was arrived at, but the conference was unanimously in favour of the fostering of any movement in the direction of the setting up of definite schemes of training. In view of the dislocation of industry likely to occur during the period of the transfer of labour from "war" work to other work, the conference agreed that it was highly desirable that centres for unemployed boys and girls should be provided during the demobilisation period. It was also decided to suggest to the Reconstruction Committee that the War Office be asked to demobilise teachers immediately upon the conclusion of peace. As regards the question of limiting the number of children entering the labour market, it was agreed that every effort should be made to persuade children attaining the school-leaving age to remain at school. Much discussion took place on proposals for the prohibition of employment for wages of children liable to attend school, and a vote taken showed a majority of 30 in favour of total prohibition. It was agreed that no child should be allowed to leave school unless there was definite employment in view. It was decided that no immediate action could be taken in regard to the prevention of the payment of inflated wages to juvenile workers.

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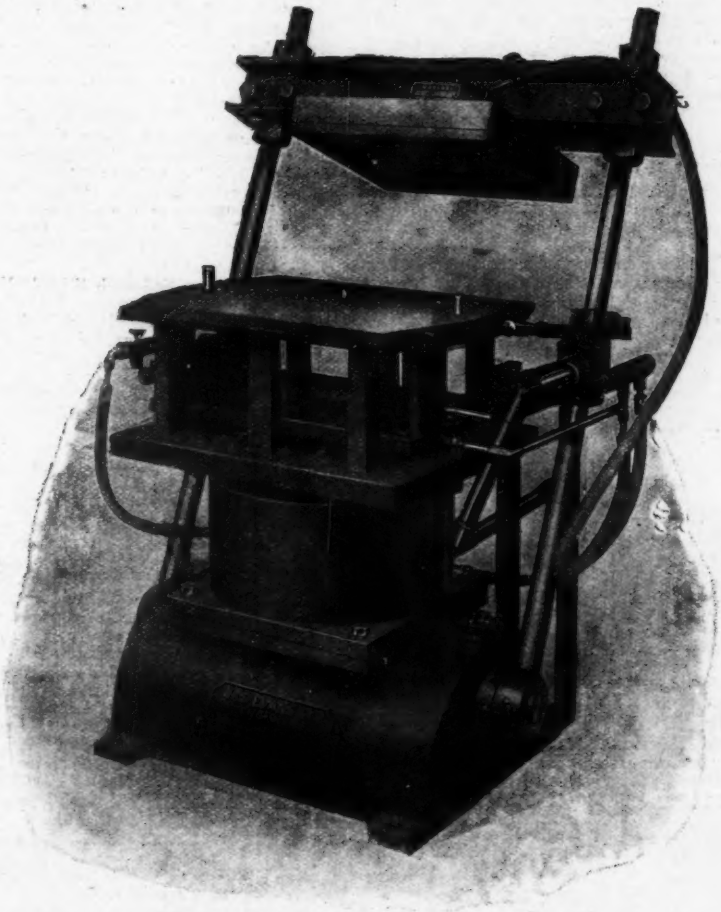

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Deaths.

THE death is reported of Lieut. B. J. Pelmore, R.E., a director of Perkins, Limited, Peterborough.

THE death has taken place of Mr. F. C. Richardson, a director of the Weardale Lead Company, Limited.

THE death is announced of Mr. J. H. Cassels, of the firm of Messrs. Pott, Cassels and Williamson, engineers, Motherwell.

THE death is announced of Captain H. E. Dixon, who was prior to the war, with the Cleveland Bridge Engineering Company, Limited.

LT. J. PARKINSON LEGGOTT, who is reported to have died of wounds, was formerly engaged in the iron foundry at Carron Works, Stirlingshire.

THE death is announced of Mr. J. Smedley, J.P., of Smedley Bros., Limited, and the Park Foundry Company, Limited, Belper. The deceased was eighty years of age.

THE death in action is reported of Lieut, B. Hollis, Black Watch, son of Mr. H. E. Hollis, a director of Messrs. Arthur Balfour & Company, Limited, of Glasgow.

SECOND-LIEUT. CYRIL V. THOMAS, R.F.A., the second son of Mr. J. H Thomas, College Square, Llanelly, manager of Thomas & Clement, Limited, Morfa Foundry, Llanelly, was killed in action on July 18.

MR. W. BRAITHWAITE, cashier to the firm of William Doxford & Sons, Limited, shipbuilders, Pallion, Sunderland, died at Keswick at the age of 51 years. He had been in the service of Messrs. Doxford ever since 1881.

MR. ALFRED MOSELY, who has practically devoted his life to the cause of industrial and educational efficiency and of Empire union, died last month at his residence, West Lodge, Hadley Wood, at the age of 62 years.

LIEUTENANT A. B. TICKLE, King's (Liverpool) Regiment, who has been killed in action, was the only surviving son of the late Mr. James Tickle, of Messrs. Tickle Bros., engineers, the Vulcan Foundry, Wigan, and of Newtown, Wigan.

THE death is announced of Mr. R. Wright, of Newcastle, at the age of 72 years. The deceased was associated with Sir W. G. Armstrong, Whitworth & Company, Limited, and was a recognised authority on the design of hydraulic machinery.

WE regret to announce the death of Lieut. W. Smeeth, R.F.C., eldest son of Mr. J. Watson Smeeth, iron merchant, of Bradford. The late Lieut. Smeeth was a young man of particular promise, and before joining the Army was associated with his father's business in Bradford.

CAPTAIN W. H. C. KIDSTON, of the Argyle and Sutherland Highlanders, has died from wounds received in action. Capt. Kidston was a partner in the firm of Messrs. A. G. Kidston & Company, of Glasgow and London. Corporal John S. Wilson, M.M. (Seaforth Highlanders), who was on the staff of the company, has also died from wounds.

CAPTAIN RUPERT OWEN BEIT, killed in action, was educated at the Central Technical College, London, after which he was with the Cleveland Bridge and Engineering Company, Limited, Darlington, as a pupil. He was in Brazil as one of the firm's engineers when war broke out. He was a grandnephew of the late Sir John Fowler, the eminent engineer.

THE death is announced of Mr. James Butler, founder of the firm of Messrs. James Butler & Company, machine tool makers, Halifax. The business was commenced in a small way, and was greatly extended until in recent years it has become one of the largest firms of tool makers in Halifax. Mr. Butler retired a few years ago. He took an active part in establishing the Halifax Technical School, and was deeply interested in the engineering section of the school.

THE death occurred suddenly on July 6 of Mr. T. Corbett, J.P., of Cotonhurst, Coton Hill, Shrewsbury, at the age of 74. The deceased was the principal of the Perseverance Ironworks, Shrewsbury. He was the manufacturer of many useful agricultural implements and machines, which he had invented and exhibited at the principal agricultural shows in this country, on the Continent, and in the Colonies, having won gold medals, diplomas, and other prizes, numbering close on a thousand.

THE death is announced of Machinist-Sergt.-Major Frederick Howard Smethurst. He was a son of the late Mr. George Smethurst, C.E., of Tring, who designed and carried out the construction of the famous hydraulic hammer at Woolwich Arsenal. The son also adopted the profession of engineer, and was managing director of the Railways Accessories Company (Limited), London, and the inventor and patentee of a safety point lever for railway trucks, which is being extensively used.

THE death is announced of Mr. James Reid Campbell, of the firm of Rossich & Campbell, Glasgow. Mr. Campbell received his training in shipbuilding with the London and Glasgow and Fairfield shipbuilding companies, and for some years was on the staff of the British Corporation Shipping Registry. He subsequently held an appointment for about 10 years as naval architect and superintendent for the Union Steamship Company, of New Zealand. Since 1915 he had been acting again for this company in addition to carrying on his own business, in the absence of his partner, who had joined the Army.

SECOND-LIEUT. BASIL WALWYN WHITE, who has been killed in action, was the only son of Mr. J. Walwyn White, of Messrs. R. White & Sons, Widnes, railway engineers and contractors. He was born in 1897, and educated first at Rhos Preparatory School, Rhos-on-Sea, and then at Sedbergh School, Yorkshire, whence he went on to Sandhurst, in the early part of 1916, passing out with a commission in the King's Liverpool Regiment, in the autumn. He then elected to join the Royal Flying Corps, and went out to France in March, 1917. He was reported missing on an expedition on April 8, and it is now officially announced that he was "killed in action" on that date.

MR. R. HEBER RADFORD, a partner in the firm of Messrs. R. Heber Radford, Son, & Squire, 15. St. James' Row, Sheffield, died on Saturday last. Mr. Radford was the eldest son of the late Mr. Joseph Radford, formerly principal of the firm of Radford & Waddington, Waterloo Foundry, Manchester, one of the founders of the Institution of Mechanical Engineers, and a member of its first Council. He served a probationary apprenticeship with Beyer, Peacock & Company, Limited, of the Gorton Foundry, Manchester. Articled in 1858 to Mr. John Brough Palmer, of Messrs. Palmer, Jarrow-on-Tyne, he was engaged from 1864 to 1868 in partnership with his father. Since 1868, Mr. Radford carried on the business established by his father, and though fresh blood was introduced into the firm, he remained actively associated with it until his death. In the course of his extensive experience he was engaged by some of the largest works in the kingdom. He had been a member of the Institution of Mechanical Engineers since 1876, and was also a member of the Institute of Naval Architects and of the Iron and Steel Institute.

CENTRIFUGAL CASTING.—For a year or two an active interest has been taken in the process of making hollow cylindrical castings in rotating moulds. Remarkable castings in steel, iron, and bronze have been made in this way. The centrifugal force developed by the high rotative speed of the mould tends to densify the metal, and at the same time gives a chance for the escape of the gas which it contains. In recent months, it is understood, a process of casting in this way has been developed with particular reference to short sections of cast-iron pipe, and an improvement has been made in the process whereby the castings are removed from the mould as soon as they are set, so that very great outputs can be obtained from a given machine. Full details are not at hand, but the process seems to promise well.

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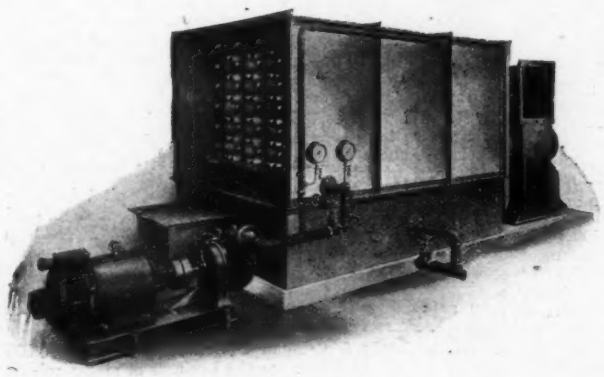

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C. S. Edgerley & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, etc.

Air Turbines, Limited.—Capital £1,000 in 2s. shares. Registered office: 38, Victoria Street, Westminster, S.W.

Piggott Electrical Company, Limited.—Capital £5,000 in £1 shares. Registered office: 24, New Bridge Street, E.C.4.

West of Scotland Copper Company, Limited.—Capital £600 in £1 shares, to adopt an agreement with J. S. Taylor.

Assorted Metals, Limited. — Capital £1,000 in £1 shares, to adopt an agreement with M. L. Jones, 117, Victoria Street, S.W.1.

Motor Gear & Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office: 75, Curtain Road, London, E.C.

Wedmore Engineering Company, Limited. — Capital £100 in £1 shares, to acquire the business of a company of the same name.

Sheffield Reduction Company, Limited. — Capital £10,000 in £1 shares, to carry on the business of thermal treaters of metals, etc.

Ransomes (Tipton), Limited.—Capital £50,000 in £1 shares, to carry on the business of civil, mechanical, and electrical engineers, etc.

Frost Patent Engine Syndicate, Limited. — Capital £1,500 in £1 shares. Registered office:—Grosvenor Chambers, Lichfield Street, Wolverhampton.

Hill & Cozens, Limited. — Capital £20,000 in £1 shares (7,000 preference), to acquire the business of Hill & Cozens, hardware merchants, brass founders, etc.

Excelsior Engineering Company, Limited. — Capital £2,000 in £1 shares, to adopt an agreement with A. Morton, E. C. Richardson, F. Rawson, and H. B. Shepherd.

Argilla Aluminium Company, Limited. — Capital £7,500 in 5s. shares. Manufacturers of aluminium and other metals, etc. Registered office: 92, Victoria Street, London.

Provincial Metal Company.—Capital of £3,000 (£1). Manufacturers, casters, founders, and dealers in aluminium, bronze, copper, etc. Office: 14, New Street, Birmingham.

G. H. Yates (Dudley Port), Limited.—Capital £6,000 in £1 shares, to take over the business of brass and metal casters, etc., at Dudley Port, Tipton, Staffs., of G. H. Yates.

Aerac, Limited.—£1,000 in 10s. shares, to carry on the business of aircraft, motor-car, and petrol and gas engine manufacturers, etc. Registered office: 7, Finsbury Square, E.C.

E. M. P. Engineering Company, Limited.—Capital £18,000 in 8,000 ordinary shares of £1 each, and 40,000 deferred shares of 1s. each. Registered office—50-52, Draycott Avenue, S.W.

R. W. Reeves, Limited.—Capital £2,000 in £1 shares, to take over the Ellesmere Engineering Works, Leigh, Lancs, of R. W. Reeves. Registered office: Portland Street, Leigh, Lancs.

Korting Brothers (1917), Limited.—Capital £15,000 in £1 shares, to carry on the business of founders, electrical and mechanical engineers, etc. Registered office: 53, Victoria Street, S.W.

Mayfield Engineering Company, Limited. — Capital £500 in £1 shares, to take over the business carried on as Charles B. Ogilvie & Company at Temperance Street, Fairfield, Ardwick, Manchester.

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¶ Installed by leading works in Sheffield.
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¶ Unskilled labour.
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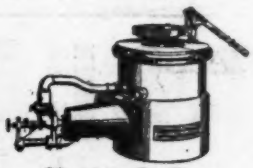

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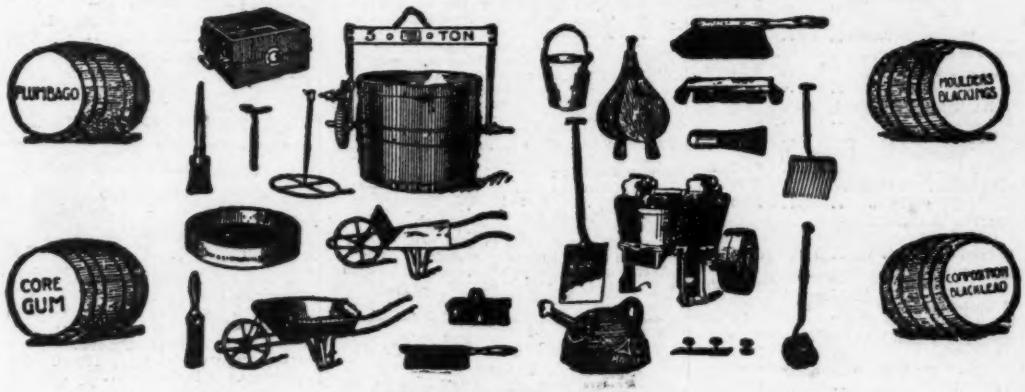

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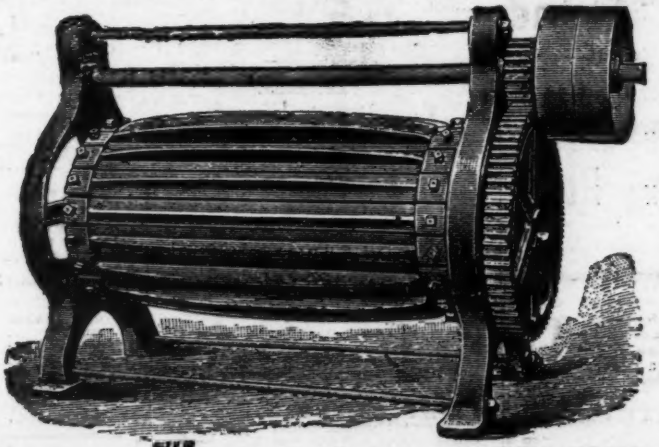

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	£ s. d.
West Coast hematite, mixed Nos. 1, 2 and 3	6 7 6
Special under 0.03 P. & S.	6 15 6
" " 0.02 "	7 0 0
East Coast hematite, mixed Nos. 1, 2 and 3	6 2 6
Special under 0.04 P. & S.	6 7
Special under 0.03 P & S.	6 15 6
" " 0.02 "	7 0 0
Scotch hematite, mixed Nos. 1, 2 and 3	6 2 6
Special under 0.03 P. & S.	7 10 0
Welsh hematite, mixed Nos. 1, 2 and 3	6 2 6
Special under 0.03 P. & S.	6 15 6
" " 0.02 "	7 0 0
HEMATITE—MALLEABLE— Refined—	
Refined Cupola Cast	8 0 0
Refined Cupola Cast to guaranteed analysis	8 5 0
Cast direct from Blast Furnaces—	
Small Pig-Iron, all grades	7 10 0
Medium Pig-Iron White to Grey mottled	7 5 0
Medium Pig-Iron, all other qualities	6 17 6
Large Pig-Iron, all grades	6 17 6
Lincolnshire, basic or foundry	4 12 6
Cleveland, No. 1	4 11 6
" other grades	4 7 6
" basic	4 17 6
Northamptonshire, forge	4 7 6
" fdy. numbers	89/0 94/0
" basic	4 17 6
Derbyshire, forge	4 10 0
" foundry numbers	92/6 96/6
Derby & Notts. basic.	4 17 6
Leicestershire & Notts., forge	4 10 0
" " foundry nos.	92/6 96/6
North Staffs, forge	4 15 0
" " foundry	4 17 6
" " basic	4 17 6
South Staffordshire—	
Part mine forge	4 15 0
" foundry	4 17 6
Common Staffordshire	4 10 0
All mine forge	5 15 0
" foundry	6 0 0
Warm air forge	7 5 0
" foundry	7 15 0
Lord Dudley's silicon	8 7 6
Cold blast	9 2 6
Basic	4 17 6
Scotch foundry and forge—	
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan	5 14 0
Nos. 3, 4, and lower grades of all other brands	5 15 6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1½%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows :—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows :—

Millings and Turnings	5d.
Bar Ends	6d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£ s. d.
Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	—
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	—
Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	—
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	—
Ferro-vanadium : 35/40% Va., per lb. of Va. contained in the alloy	—
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit Per ton	—
Ferro-titanium : 23/25%, per lb. carbonless	—
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained	—
Ferro-phosphorus : 20/25%. Per ton	—
Ferro-tungsten : 75% to 80% per lb. of metallic tungsten contained	—
*Ferro-manganese 80%	25 0 0
" export £36 0 0	—39 0 0

* F.o.b. Liverpool.

Non-Ferrous Metals.

	£ s. d.	£ s. d.
Copper.		
Standard, Cash	120 0 0	120 10 0
Three months	119 10 0	120 0 0
Electrolytic	137 0 0	133 0 0
Tough	135 0 0	131 0 0
Best selected	135 0 0	131 0 0
Tin.		
Standard, Cash	243 5 0	243 10 0
" Three months	242 5 0	242 10 0
English Ingots	—	239 10 0
Bars	—	240 10 0
Refined	—	—
Spelter.		
American	54 0 0	50 0 0
Specials	—	—
Hard	—	—
British	—	—
Lead.		
Soft Foreign	30 10 0	20 10 0
English	—	Nom.
Antimony.		
Regulus	—	85 0 0
Aluminium.		
Virgin Metal 98/99% per ton	—	—

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots	—
CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid	—
" Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. 35/- above price of best selected copper.

15 per cent. Phosphor Copper .. 40/- above price B.S.

Phosphor Tin (5 per cent.) .. £23 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM)

***Chromium (Metallic).**	
98/99% purity, per lb.	—
***Nickel.**	
In cubes, 98/99% purity Per ton	—

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks	—
" rolled to spoon size	—
***Tungsten Metal Powder.**	
96/98% purity.. per lb.	—
***Molybdenum Metal.**	
96/98% purity.. per lb.	—
***Cobalt Metal.**	
97% purity .. per lb.	—
Quicksilver.	
75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

	s. d.	s. d.
Cleveland.		
Steel scrap, heavy melting	105 0	—
Iron scrap cast (cupola metal)	90 0	95 0
London (f.o.b.).		
Heavy steel		110 0
Light "		55 0
Heavy cast		95 0
Control Prices.		
Heavy Steel Melting Scrap	105 0	125 0
Turnings and Borings		50 0
Wrought Iron Scrap	105 0	125 0

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations :—

	A. Joseph. £ s. d.
Hy. Electrolytic Copper Scrap	—
Hy. Selected Scrap Brass	—
Hy. Tinned Copper Wire	—
Best Selected Gunmetal Scrap	—
Re-melted Ingot Lead	—

Stocks.

Metals.	Tons.
Copper, Europe and afloat	—
Tin, London, Holland, U.S.A. and afloat	—

Coke.

	s. d.	s. d.
Middlesbrough.		
Gas Coke	29 0	—
Glasgow.		
Foundry Coke	—	42 0
Furnace Coke	30 0	—
Gas Coke	—	
London.		
Welsh or Durham Foundry, d/d London Stations in truck	45 6	53 0
Ditto, d/d Birmingham Stations	44 0	48 0
Yorkshire, d/d London Stations, in truck	42 6	—
Ditto, d/d Birmingham Stations	39 6	—

CONTROL PRICES OF COKE.

	s. d.
Durham and Northumberland blast furnace	28 0
" foundry	30 6
South Yorkshire, West Yorkshire, Lancashire, Staffordshire and Midland Counties blast furnace	25 8
South Wales blast furnace	30 0
" foundry	43 0

All per ton net. f.o.t. ovens.

SITUATIONS VACANT AND WANTED.

WANTED, SECRETARY-MANAGER for Steel and Iron Foundry, South Wales, doing Munition and Colliery work.—State age, experience and salary required to Box 900, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN for Foundry, practical man, used to loam and other castings; good disciplinarian; Government work.—MONOMETER MANUFACTURING Co., Whitehouse Street, Aston; or Albion Foundry, Browning Street, Ladywood.

FOREMAN WANTED for Iron Foundry producing small castings with a thorough knowledge of up-to-date moulding machines. A good permanent post for a reliable man. Foundry at present occupied on Government Work. No person already on Government Work will be engaged.—Apply your nearest Employment Exchange, mentioning this Journal and No. 894.

FOUNDRY MANAGERS, PLEASE NOTE.—Odd sides to register, made in plaster, are heavy or cost pounds; but by using rough wooden box parts and Turner's Patent Sockets, they will cost shillings.—TURNER, 28, Plumpers Road, Sheffield.

ABSTAINER, 28, good general experience in moulding, including plate — Member B.F.A. — would like position of trust.—Address Box 890, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN or Yard Manager required for Controlled Factory employing about 200 men, casting Brass and other Metals. The applicant must have had experience in controlling and organising labour—he should also have some knowledge of Machinery, but not necessarily of Foundry practice. None but hard-working energetic men need apply. Good wages.—Apply, stating age and give full details of experience, to your nearest Employment Exchange, mentioning this Journal and No. 896.

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PARTICULARS and prices required for second-hand Edge Runner with Granite Wheels about 12 in. to 15 in. diameter, and Granite Bed.—Box 892, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PATENT No. 108,426, of 1916, relates to a drop flask Moulding Machine, whereby the system of moulding is rapid, accurate and inexpensive. Sale or licence.—TURNER, 28, Plumper's Road, Sheffield.

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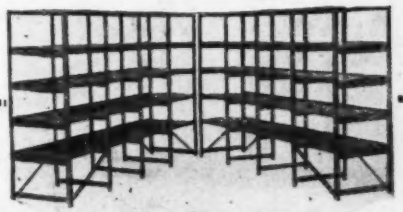

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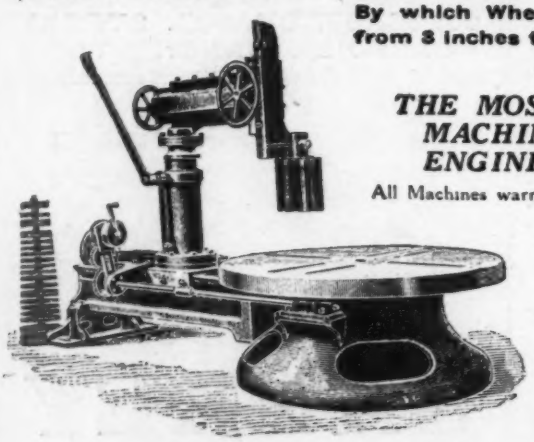

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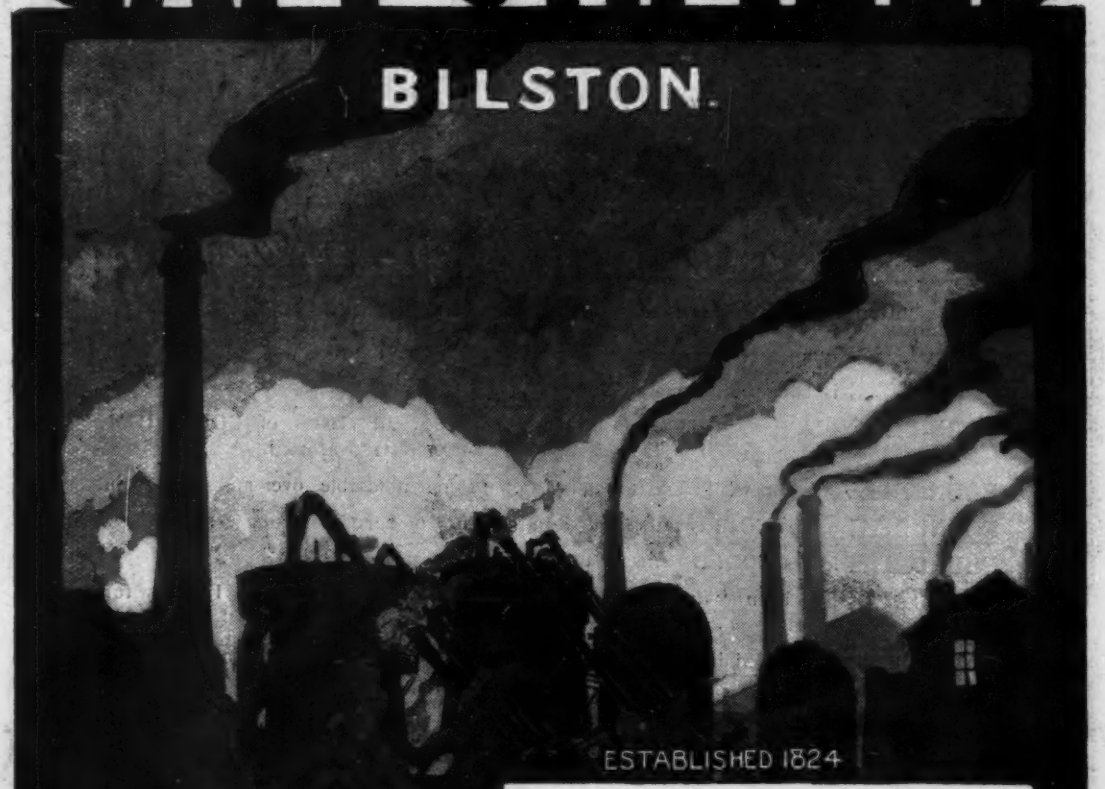

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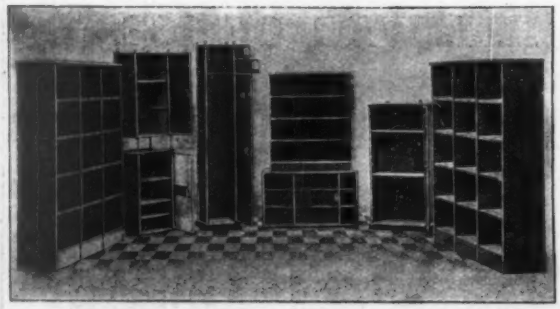

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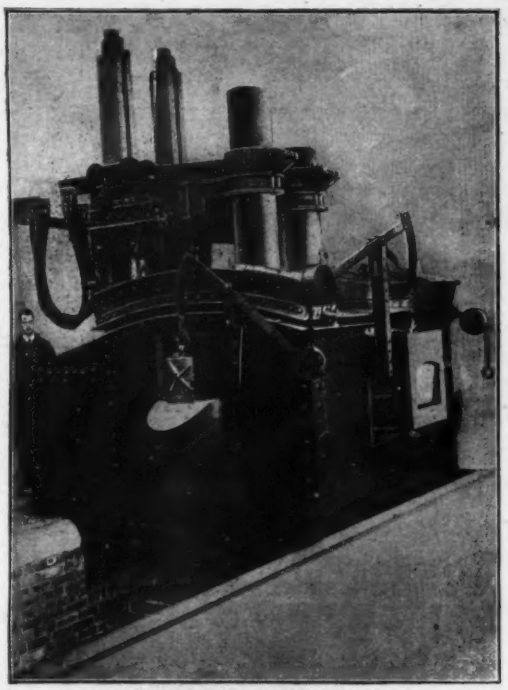

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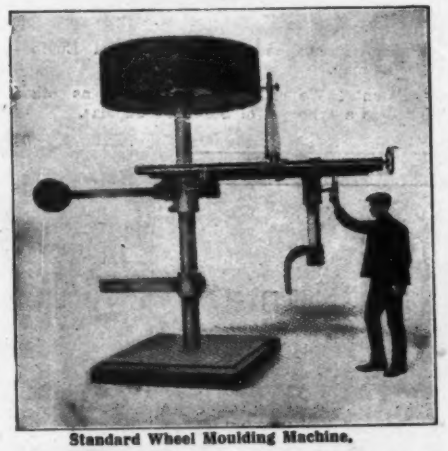

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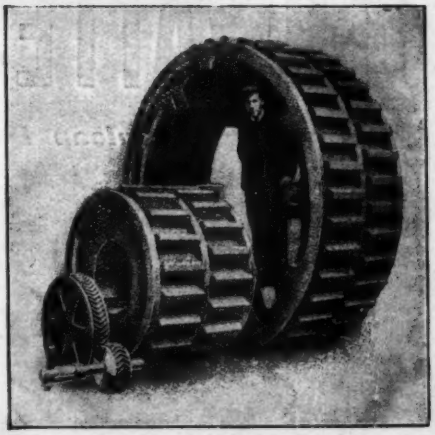

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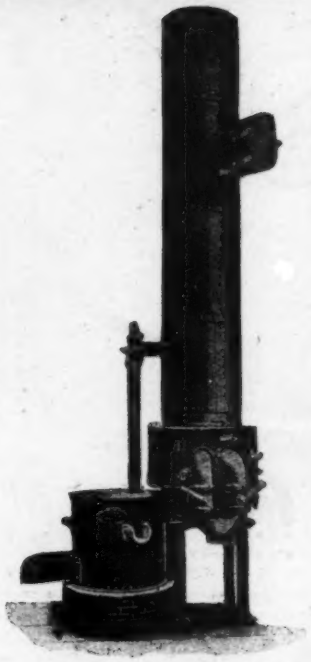

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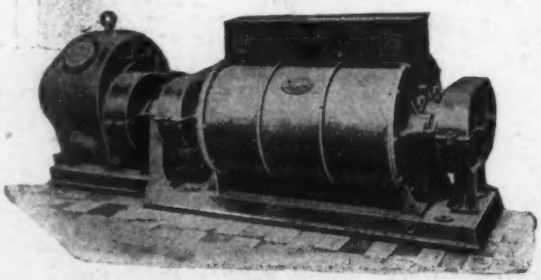

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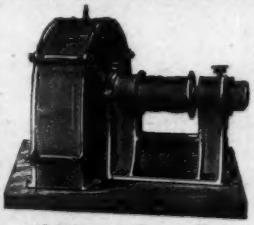

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